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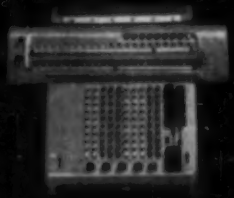

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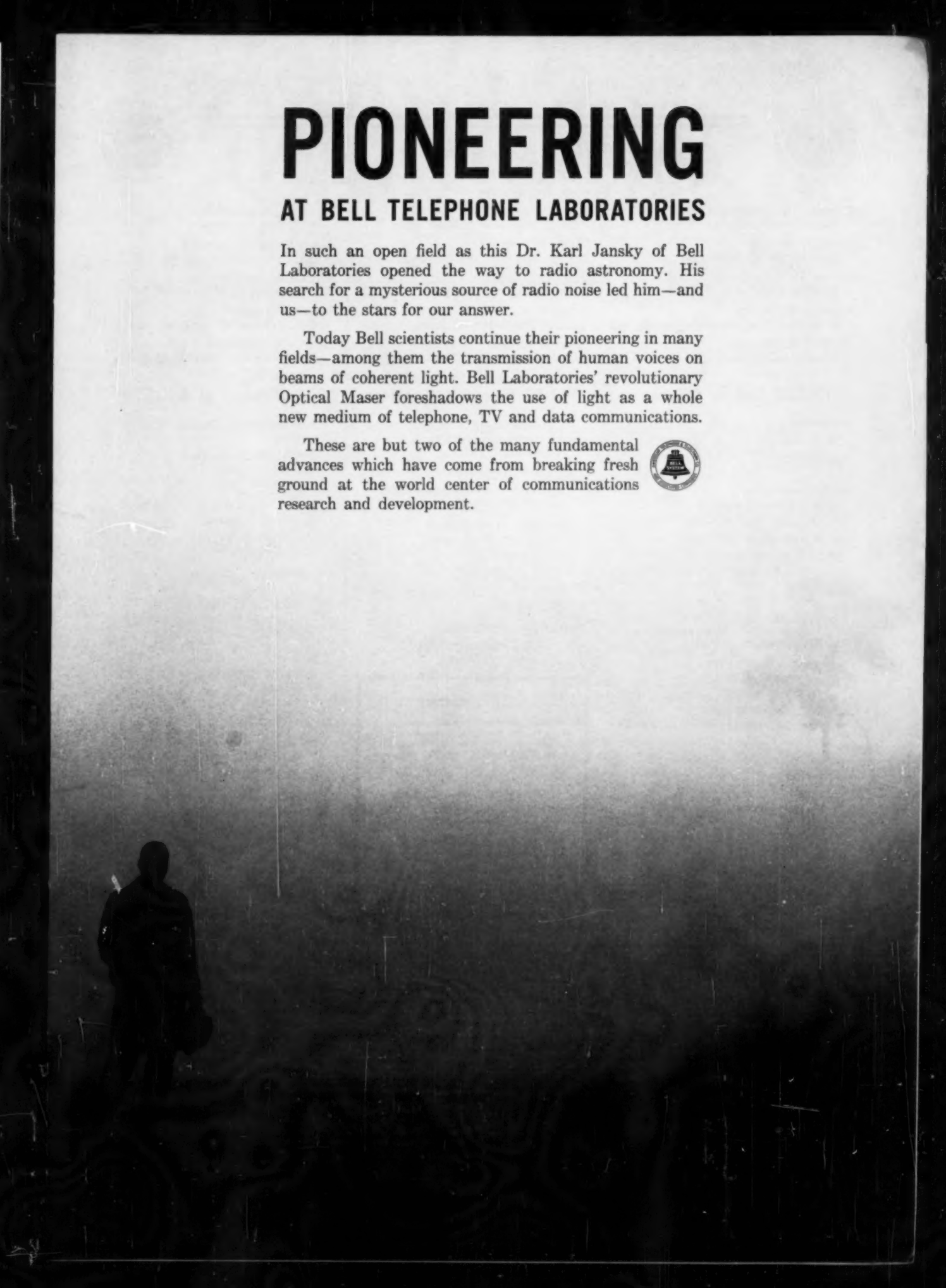

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Power Characteristics of Control Charts

EDWIN G. OLDS

Carnegie Institute of Technology

Introduction

This article will present a brief summary of results obtained by the author and several of his graduate students at Carnegie Institute of Technology during the past decade. Since September, 1954 the research has been sponsored by the Office of Ordnance Research, U.S. Army.

The application of statistical quality control has two phases. The first phase is described[12] as "control when no standard is given" and the second phase as "control with respect to a given standard." The operating characteristics of the average and range charts in the second phase, for the case when the measured quality characteristic has a Gaussian (normal) distribution, were given in a fundamental paper[16] by Scheffe in 1949. The investigations to be discussed here have been concerned mainly with power characteristics of the control test in the first phase — the phase where the control chart is, in the words of Z1.3[2], used "for analyzing past data." Control charts for both counts and measurements are considered but, in the latter case, results can be given only when the assumption of normality is imposed.

Actually, the recognition of the need for the investigation of power characteristics for the first phase antedated the "fabulous fifties" by at least another ten years. It was strongly emphasized by the embarrassment of the author when he was associated with the Office of Production Research and Development during the last war and was faced with the problem of explaining why the control chart works. He was forced to restrict himself to making definite statements about phase two because specific information regarding phase one was almost completely lacking.

An incident at one of the intensive eight-day courses, organized by the Office of Production Research and Development, was particularly disconcerting. (For information regarding the intensive courses see (20) and (13)). Early in this course on "Quality Control by Statistical Methods," the behavior of samples from a controlled process was simulated by the drawing of twenty-five samples of five chips from the same bowl. As usual, averages and ranges were calculated and plotted. Then control limits were calculated and placed on the charts. To the surprise of the demonstrator, one point on the chart for averages was outside the control band. Here was a process said to be in a state of control but the test for control contradicted the advance billing. Naturally, students were eager to know whether the demonstrator switched bowls for the drawing which gave the maverick. If not, then "How often would at least one point be out?"

Quite precise answers to the above question and other related ones are now available and will be given.

Fundamentals

In order to clarify the exposition it seems useful to begin by reviewing a few statistical concepts and emphasizing certain distinctions. First the difference between state, hypothesis, and test is demonstrated by the following example.

An automobile battery may be in one of two states — dead or not dead. For some reason the hypothesis is put forward or the conjecture is made that

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the battery is dead. This hypothesis may be correct; one hopes it is wrong. Anyway, it is tested. Perhaps the test is to turn the ignition key on and to note whether or not there is a response. This test differs from the usual statistical test because there is no possibility of a Type I error—that is, there can be no false indication of life if the battery really is dead. On the other hand there is the possibility of making a Type II error because, under certain conditions, one might have a live battery but get no response and so conclude that the battery was dead. In passing, it might be mentioned that, without a precise definition, there could be lack of agreement on the proper word to be used to describe the state of the battery.

A process, which has been set up to produce one ten-penny nail after another, may have been in a state of control during an eight-hour period or it may not. At each moment when a nail was to be produced the probability that the nail would be good might be the same. Furthermore, this marginal probability might be the same as the conditional probability when any sequence of good and bad nails had been produced previously. If both of the above conditions held, then the author would say that the process had been in strict control for the eight-hour period.

This description of strict control has been formalized by the following definition which was given by the author[10] at the Ninth Annual Convention of the American Society for Quality Control.

> "A process is in control in the strict sense during the time T_P, when
> (1) $f(x)$ is identical for every $x(t)$, with t in the interval, T_P, and
> (2) the set of random variables $[x(t)]$ are statistically independent."

It should be emphasized that for this first phase, control when no standard is given, $f(x)$ is not specified in advance. Furthermore, it is not known, although for a controlled process it can be estimated.

Contrast the usual definition for control with respect to a given standard,

> "A process is in control at a time t, with respect to a standard, $f^*(x)$, if $f(x)$ is equal to $f^*(x)$."

Note that this definition refers to the state of the process at a specific time, t.

The test for control, when no standard is given, is well known. It is performed only after a set of samples have been drawn. It leads to the decision that the process is in a state of control only if all points are within their respective control bands.

On the other hand, a test for control with respect to a given standard is made after each sample is drawn. For example, twenty samples give twenty tests while, for the previous case, a set of twenty samples gives just one test.

Of course, as the author has suggested[10], it might be desirable to revise the procedure in the second phase and test for control with respect to a standard for a time period, T_s. Then the hypothesis of control will be accepted only if all points are within limits. Here, of course, the limits depend on the standard and can be set in advance. (It may be worth mentioning that a process may be in a state of control for a period, T_s, without being in a state of control with respect to the given standard.)

Usually, except, perhaps, for defect-per-unit charts, samples consist of measurements or counts for more than one unit. If the process is in a state of control, no logical difficulty is encountered. However, any hypothesized alternative to control should include the assumption that the process is in control during each minimum time interval during which a sample is taken.

The Control Chart for Defects Per Unit

Rather than follow the chronological order of the investigative work, it seems best to begin with a discussion of power characteristics of the control chart for defects per unit. An industrial process is postulated such that, at any time t, the probability that a unit will have x defects is given by

$$f(x) = \frac{(c')^x e^{-c'}}{x!} \qquad x = 0,1,2,\ldots . \quad (1)$$

where c' may vary with time. It is assumed that k units will be inspected during the time T_P and that $c_1, c_2, \ldots, c_k$ will represent, in order of time, the numbers of defects found for the k units. Furthermore, $\bar{c}$ will symbolize the arithmetic mean of the c-values and UCL and LCL the upper and lower control limits.

While it is customary to use 3-sigma limits, there seems to be justification for using a-sigma limits in some cases, with a chosen to be some multiplier different from 3. Therefore, this procedure has been considered. Also the effect of using only a single limit has been investigated.

If, during the period T_P, a total of N units are produced, then the process will be said to be in a state of strict control if, and only if,

$$f(x_1,x_2,\ldots x_N) = \prod_{i=1}^{N} f(x_i) \qquad (2)$$

where the symbol on the left is the point density for the indicated random variables and where $f(x_i)$ is given by (1) with x written for x_i and with c' the same for all x_i. (Π, of course, means "product.")

The test for control is based on the use of the control limits to bound a control band. A set of k samples are taken in order of production and limits, given by the following formulas, are calculated.

$$\begin{aligned} UCL &= \bar{c} + a\sqrt{\bar{c}} \\ LCL &= \bar{c} - a\sqrt{\bar{c}} \end{aligned} \qquad (3)$$

If only an upper control limit is to be used, then the control band is bounded by $x = UCL$ and $x = 0$. The latter line is part of the control band but the former line is not a part of it unless it coincides with the latter line. If two control limits are to be used, then neither is a part of the control band except when both coincides with $x = 0$.

The hypothesis of control is rejected if one or more points fall outside the control band. Otherwise it is accepted. Then P_A, the probability of accepting the hypothesis that the process has been in a state of control during T_P, is given by

$$P_A = \text{Prob}\,(LCL<x_1<UCL, \ldots, LCL<x_k<UCL) \qquad (4)$$

It should be emphasized that the test rejects the hy-

Table I—Upper Bounds for Probability of Type I Error for Upper Three-Sigma Limit Control Chart for Number of Defects, No Standard Given

c′	k = 10	15	20	25
0.1	0.036	0.294	0.360	0.811
0.2	0.086	0.281	0.315	0.491
0.3	0.109	0.202	0.301	0.351
0.4	0.111	0.165	0.262	0.285
0.5	0.104	0.148	0.228	0.265
1.0	0.070	0.117	0.164	0.213
2.0	0.039	0.076	0.106	0.147
3.0	0.032	0.061	0.087	0.118
4.0	0.030	0.055	0.080	0.106
5.0	0.026	0.049	0.072	0.095
7.0	0.024	0.044	0.063	0.085
10.0	0.021	0.039	0.055	0.072
15.0	0.018	0.033	0.049	0.063
20.0	0.016	0.030	0.044	0.058

pothesis if one or more points are outside the control band.

When the process is in a state of control the probability, α, of one or more points being outside the band, making the Type I error of rejecting the null hypothesis, is equal to $1 - P_A$. When the process is not in a state of control, the probability, $1 - \beta$, that the correct decision to reject the null hypothesis will be reached is $1 - P_A$. This is the power of the test. Obviously it will depend on the nature of the alternative state. (β, of course, is the probability of accepting the null hypothesis when it is false.)

In significance testing it has been the usual practice to fix α. Ordinarily the value chosen is 0.05. In hypothesis testing, where possible alternatives are considered in advance, it is customary to specify, also, the value of β for a particular alternative and then let the value of α and β determine the amount of information needed.

For the control chart, α is a function of c′, k, and a. There may be an idea that α will be constant if k and a are fixed at some values such as 25 and 3. Such is not the case because α still varies with c′. In general, the computations necessary to get the exact value of α are lengthy. However, it is relatively easy to calculate upper and lower bounds for α which are close together. The procedure, which is based on the use of Bonferroni Inequalities is described in several reports (12,11,14,9). As indicated in these documents, the upper bound used for α is close to the exact value of α when k is not too small. This upper bound, α_U tends to α as k tends to infinity. In any case, a study of the behavior of α_U is very helpful in revealing the performance of α.

Some indications of the variation of α_U with changes in c′,k, and a, are given by Table I (compiled by extracting part of Table II from (14) p. 12 and rounding off the entries to three decimal places) and by Table II (obtained in similar fashion from Table IV-10[9] p. 33). In Table I it might also be noted that all of the entries for k = 25 exceed 0.05 and that the excess increases rapidly as c′ decreases. For k = 10, α_U has a maximum near c′ = 0.4 and then decreases as c′ increases. In every case α_U increases with k when c′ is held constant. (Is this a desirable condition?)

Table II—Upper bounds for Probability of Type I Error for Upper a-Sigma Limit Control Chart for Number of Defects, No Standard Given, When k = 10.

c′	a = 2.6	2.8	3.0	3.2
1	0.117	0.075	0.070	0.041
2	0.093	0.066	0.039	0.027
3	0.082	0.053	0.032	0.022
4	0.072	0.048	0.030	0.018
5	0.070	0.044	0.026	0.016
7	0.064	0.039	0.024	0.014
10	0.059	0.036	0.021	0.012
15	0.054	0.031	0.018	0.010
20	0.050	0.029	0.016	0.009

Table II indicates the effect of changing the multiplier of sigma in the expression for the upper control limit. Study of the two Tables suggests that, if c′ can be fairly well estimated in advance, it may be possible to choose (k,a) combinations for which the probability of a Type I error will be somewhere near 0.05. Some (c′,k,a) combinations which approach this goal are given in (9), p. 36. Among the better ones listed are (1,5,2.5), (1,25,3.8), (2,15, 3.2), (2, 25, 3.5), (4,20,3.2) and (4,25,3.3). It should be mentioned that only results for c′ = 1,2,4 are tabulated.

It might, perhaps, be suspected that the use of charts with both upper and lower control limits would have a considerable effect in altering α_U. Such is not the case unless c′ is considerably larger than a $\sqrt{c'}$. It is interesting to know that, if a table like Table I were given here for charts with both upper and lower 3-sigma limits, only ten entries (all in the last three rows) would be increased and the largest increase would be 0.009 (at c′ = 20.0, k = 25).

The Question of Power

Turning now to the question of power, it is obvious that there are a host of alternatives to strict control which might be listed. The first alternative to be considered here is one which has been called a single slippage. Suppose the total time interval has been divided into k sub-intervals and that the process is assumed to be in strict control during each of the sub-intervals. If, for k—1 of these sub-intervals, c′ is equal to c_1', but for one of these sub-intervals, c′ is equal to c_2' which is different from c_1', then the state of lack of control will be called a single slippage. Double slippages of equal amounts, a second alternative to be considered, is the case when c′ is equal to c_1' for k—2 of the sub-intervals and is equal to c_2' (different from c_1') for the other two. In each case the data for performing the test for control will consist of a sample of one unit from each sub-interval.

If the first alternative (single slippage) correctly describes the true state of lack of control, then one of three mutually exclusive events can occur:

- E_1 all points in the control band
- E_2 the point corresponding to $c' = c_2'$ outside the control band (and, perhaps, other points also outside)
- E_3 the point corresponding to $c' = c_2'$ *inside* the control band but one or more of the other points outside the band.

In the control chart operation either E_2 or E_3 is the signal to search for an assignable cause. The initial search, at least, probably will be concentrated on conditions characteristic of the sub-interval generating the out-of-control points. In the case of E_2 the search will include the sub-intervals where the process has slipped and so the probability of E_2 is called "the probability of detecting a single slippage." The event, E_3, correctly signals trouble but does not indicate the proper direction for the initial search. There-

Table III—Power of the Upper Three-Sigma Limit Control Chart for Number of Defects, No Standard Given, to Detect a Single Slippage

	k = 10		k = 25	
c_2'	$c_1' = 1$	$c_1' = 5$	$c_1' = 1$	$c_1' = 5$
1	0.007		0.009	
2	0.059		0.078	
3	0.176		0.229	0.000
4	0.338	0.000	0.419	0.001
5	0.507	0.003	0.598	0.004
7	0.774	0.027	0.844	0.039
10	0.950	0.185	0.973	0.244
15	0.998	0.676	0.999	0.756
20	1.000	0.939	1.000	0.965

fore, the probability of E_3 often is referred to as "the probability of a Type III error." Obviously

$$1 - \beta = \Pr(E_2) + \Pr(E_3) = 1 - \Pr(E_1) = 1 - P_A \quad (5)$$

Extensive tables for the probabilities for the detection of single and double slippages are given in the referenced reports. A few numbers have been chosen and rounded off in order to form the basis for Tables III and IV, which are given here. Study of Table III reveals that the power to detect a single upward slippage is somewhat greater for $k = 25$ than it is for $k = 10$. The improvement is not as great as might be expected in view of the fact that, for $c' = 1$ and $c' = 5$, α_{II} is between three times and four times as large for $k = 25$ (see Table I). Furthermore, two and one-half times as many samples are required.

Inspection of Table IV reveals, as expected, that an increase in a is accompanied by a decrease in power. If both Tables III and IV are used in order to compare the power of the 2.6-sigma chart for $k = 10$ with the 3-sigma chart for $k = 25$, one may be surprised to find that the former has more power for many tabulated combinations. This is the situation in spite of the fact that the Type I errors are less (see Table I and II). The complexities of the general control problem are such that any firm generalization seems hazardous but results do suggest that it might be better to use samples from much fewer than twenty-five sub-intervals for the first phase. This is a matter, however, which requires further study. What does seem clear is the fact that, after the value of k is chosen, some attempt should be made to estimate c' in order that the multiplier of sigma can be so fixed that the value of α will be realistic.

A method of procedure has been obtained for calculating the power of the upper a-sigma limit chart to detect a double slippage of equal amounts. Detection here is to be interpreted as meaning that at least one of the slippages produces a point which falls outside the control band. Some calculations for cases where $a = 3$, $k = 5, 10, 20$ have been made. For $k = 5$, the power is less than the power to detect a single slippage for the (c_1', c_2') combinations which were used. For $k = 10$ and $k = 20$, the inequality was reversed. For $k = 10$ and $c_1' = 1$ the double slippage power values for $c_2' = 1, 3, 5, 10$ were 0.014, 0.227, 0.583, and 0.982, respectively. The corresponding single slippage power results were 0.007, 0.176, 0.507 and 0.950.

Table IV—Power of the Upper a-Sigma Limit Control Chart for Number of Defects, No Standard Given, to Detect a Single Slippage When k = 10.

	a = 2.6		a = 2.8		a = 3.0		a = 3.2	
c_2'	$c_1' = 1$	$c_1' = 5$	$c_1' = 1$	$c_1' = 5$	$c_1' = 1$	$c_1' = 5$	$c_1' = 1$	$c_1' = 5$
1	0.012		0.007		0.007		0.004	
2	0.085		0.064		0.059		0.042	
3	0.231	0.000	0.193	0.000	0.176		0.140	
4	0.412	0.001	0.365	0.001	0.338	0.000	0.288	0.000
5	0.586	0.007	0.541	0.004	0.507	0.003	0.454	0.002
7	0.831	0.055	0.803	0.039	0.774	0.027	0.736	0.019
10	0.968	0.262	0.961	0.230	0.950	0.185	0.938	0.147
15	0.999	0.776	0.998	0.726	0.998	0.676	0.997	0.620
20	1.000	0.967	1.000	0.954	1.000	0.939	1.000	0.920

The Control Chart for Fraction Defective

Since an account of the author's research on power characteristics of the control chart for fraction defective has been issued by this Society as General Publication No. 4[11], it seems unnecessary to devote much space to it in this summary. It might be mentioned, however, that some of the methods developed for it were useful in connection with the investigations described in the previous section of this summary. On the other hand, these later investigations led to the development of theory which can be helpful in extending the results previously reported. For example, a proof was obtained for the conjecture that, for $np_1' = c_1'$ and $np_2' = c_2'$, the power of the upper three-sigma limit control chart for fraction defective, no standard given, to detect a single slippage converges to the power of the corresponding chart for defects per unit. Later this result was generalized so as to include lower limit charts and charts with both upper and lower limits.

The Control Chart for Sample Means

As stated in the introduction, the need to investigate the power characteristics of the control chart in phase one was emphasized by the failure of the control chart for means to behave nicely in a public demonstration. Some time in the late forties, E. P. King, then a graduate student, became interested in the problem and, in 1951, completed a doctoral dissertation at Carnegie Institute of Technology, entitled, "The Operating Characteristics of the Control Chart for Sample Means When Process Standards Are Unspecified." Dr. King's original results and later extensions were reported in three published papers[5,6,7] and in a presentation to this Society at the Seventh Midwest Quality Control Conference, at Indianapolis, in November, 1952. His work was especially noteworthy, not only because of the specific findings, but also because it initiated on a firm foundation a series of investigations into the general problem now under discussion.

A very brief summary of King's dissertation can be written by paraphrasing his own synopsis. He investigated the Type I and Type II errors for the control chart for averages with no standards given. The hypotheses assumed an underlying normal distribution but allowed random fluctuation in the process mean. Results were tabulated for cases ranging from two samples of two to 25 samples of ten. The effect of altering the traditional three-sigma limits was discussed and the probability of a Type II error was compared with the corresponding probability for the traditional analysis of variance test.

King studied the control chart for means which is based on k samples of n units each and has a-sigma control limits. (King's notation has been changed slightly in order to avoid confusion.) He assumed that the ith sample of n, corresponding to the ith time interval, consisted of observations x_{ij} on random variables normally and independently distributed with mean μ_i and variance σ^2. Further, he assumed

that the means were normally and independently distributed with mean zero and variance $\theta^2\sigma^2$. Explicitly $x_{ij} = \mu_i + \varepsilon_{ij}$ ($i = 1,2, \ldots, k$; $j = 1,2, \ldots, n$), with the μ_i NID$(0,\theta^2\sigma^2)$, the ε_{ij} NID$(0,\sigma^2)$ (all i,j), and the ε_{ij} and μ_i statistically independent. It should be noted that (1) σ^2 is unknown, but constant, (2) there is no loss in generality in assuming that the expectation of μ_i is zero, and (3) this is the usual model for the one-factor analysis of variance with random components (Model II) with the exception of the assumption just discussed above.

For the control chart test based on sample means, King investigated the probabilities of the Type I and Type II errors for the null hypothesis, $\theta = 0$, versus the alternative, $\theta > 0$. Writing

$$\beta(a|\theta) = \Pr(|\bar{x}_1 - \bar{\bar{x}}| < aA_2\bar{r}/3, \ldots |\bar{x}_k - \bar{\bar{x}}| < aA_2\bar{r}/3) \quad (6)$$

and

$$\beta_o(a|\theta) = \Pr(|\bar{x}_1 - \bar{\bar{x}}| < a\sigma/\sqrt{n}, \ldots |\bar{x}_k - \bar{\bar{x}}| < a\sigma/\sqrt{n}) \quad (6')$$

where $\bar{r}$ is the mean of the k sample ranges, then

$$\alpha(a) = 1 - \beta(a|0) \quad (7)$$

where $\alpha(a)$ is the probability of the Type I error when a-sigma limits are used.

King found a way to calculate exact values of β_o which proved feasible for k small but became so complex for k greater than four that, for the larger values, he contented himself with getting bounds for β_o. Also, by means of series expansions and numerical integration, he was able to get a series expansion for β in terms of β_o and central moments of the range distribution. For the mathematical details of the solution, the reader is referred to (5).

Values have been abstracted from King's dissertation in order to prepare Table V.

Several comments regarding Table V and its implications might be made. In the first place, later work by Sorensen (15) seems to confirm King's conjecture that his lower bounds for β serve as good approximations to the exact values when k is large. Secondly, values for α can be obtained by subtracting from unity the β-values for $\theta = 0$. Thus α is 0.01 for $k = 4$, $n = 5$ and is between 0.03 and 0.06 for $k = 25$, $n = 5$. (Sorensen's work indicates that the exact value for the latter case is close to 0.07 so, perhaps, an unfortunate accumulation of rounding off errors occurred.) In the third place, just as for the two charts discussed previously, α increases with k. (But, for this chart, α does not depend on any unknown parameters.)

Impelled by C. C. Craig's paper (3), King compared the power of the test using the control chart for means with that of the analysis of variance test. Comparisons would not be valid, of course, unless the α for the F-test were set at the same level as for the control chart test, and, as has been noted, the value is not, in general, 0.01 or 0.05. Using the Incomplete Beta Function and the work of Ferris, Grubbs and Weaver, proper adjustments were made and comparisons were obtained. From his results, King came to the expected conclusion that the analysis of variance is definitely more powerful under this particular alternative hypothesis. He noted, however, that the difference in power appeared to decrease markedly with increasing θ. More extensive comparisons are given in King's dissertation. It may be sufficient here to note that, for $\theta = 0$, 0.25, 0.50, 0.75, and 1.00, the power values for the control chart test, (as calculated using the lower bound for β), for the case $k = 25$, $n = 5$, are 0.06, 0.19, 0.67, 0.97, and 1.00 respectively, while the corresponding values for the analysis of variance test are 0.06, 0.28, 0.85, 0.99, and 1.00.

Table V—Power, under the Normality Assumption, of the Three-Sigma Limit Control Chart for Means, No Standard Given, Against Model II Alternatives
For k = 25, only bounds are given

θ	k = 4		k = 25	
	n = 5	n = 10	n = 5	n = 10
0	0.01	0.00	0.03 0.06	0.03 0.06
0.25			0.10 0.19	0.20 0.36
0.50	0.13	0.26	0.44 0.67	0.77 0.95
0.75			0.82 0.97	0.98 1.00
1.00	0.49	0.73	0.97 1.00	
2.00	0.87	0.95		
3.00	0.95	0.98		

Recently, Sorensen[15] decided to attempt a verification of a conjecture of Wallis and Roberts,[19], pp. 498-501, and others that, for some alternatives, the test using the control chart for sample means, no standard given, is more powerful than the analysis of variance test. He postulated the same mathematical framework and sampling procedure as King did but replaced the alternative hypothesis that the sub-interval means where NID$(0,\theta^2\sigma^2)$ with $\theta > 0$, by alternatives which consisted of various types of slippages. His five alternatives were:

1. A single mean has slipped,
2. Two means have slipped equally to opposite sides,
3. Two means have slipped equally to the same side,
4. The means follow a linear trend,
5. Half the means are at each of two levels. (If k is odd, one mean is assumed to be midway between the two levels)

Sorensen attacked again the general problem of getting exact values for α and β. The equations

$$\beta(a|\mu_1/\sigma, \ldots, \mu_k/\sigma) = \Pr(|\bar{x}_1 - \bar{\bar{x}}| < aA_2\bar{r}/3, \ldots, |\bar{x}_k - \bar{\bar{x}}| < aA_2\bar{r}/3) \quad (8)$$

and

$$\beta_o(a|\mu_1/\sigma, \ldots, \mu_k/\sigma) = \Pr(|\bar{x}_1 - \bar{\bar{x}}| < a\sigma/\sqrt{n}, \ldots, |\bar{x}_k - \bar{\bar{x}}| < a\sigma/\sqrt{n}) \quad (8')$$

An approach similar to King's was used in obtaining an expression for β which depended on β_o. For $k > 3$ difficulty was encountered in getting β_o for the alternatives considered. The problem was solved by utilizing a series expansion for which convergence was established with considerable difficulty. It is expected that the details of the mathematical analysis will be published elsewhere.

A state of strict control exists when $\mu_1 = \mu_2 = \ldots = \mu_k$. The alternative of a single slippage is specified when μ_i is equal to $\mu + \delta\sigma$ and the other $k - 1$ means are equal to μ. Obviously, the direction of the slippage depends on the sign of δ. As before, there is probability that the mean of the sample from the ith sub-interval will be outside the control band and

this is designated as the probability of detecting the single slippage. But the power is the probability that, for this alternative state, at least one sample mean will be outside the control band. Therefore, for k more than two, the latter probability will exceed the former. For the three-sigma limit chart, both of the above-named probabilities have been calculated for a useful variety of combinations of k and n. It is hoped that the extensive tables and graphs of the results will be published in *Industrial Quality Control*. For the present purpose, a few numbers have been abstracted in order to form the Table given below. These numbers give the correct indications of variation (except for rounding off effects). Note that (1) α increases with k but decreases with n, (2) power (a) is greater than power (b) and both increase with k, n, or δ.

As noted above, α varies with k and n. It also decreases with a. For a set of (k,n) combinations, values of a for which α is equal to 0.05 have been calculated. For (10,5) (20,5), (25,5), the values are 2.79, 3.03, and 3.10 respectively. For n large (i.e. sigma known), the values for $k = 10, 20, 25$ are 2.65, 2.94, 3.02. For each such a-value and (k,n) combination it is possible to calculate the power to detect each of the five kinds of slippages listed above. Therefore, power comparisons with the analysis of variance test can be made.

Tang[17] found that the operating characteristic for the Model I alternatives can be expressed as a function of the non-centrality parameter

$$\phi^2 = (n/k\sigma^2) \sum_{1}^{k} (\mu_i - \bar{\mu})^2 \qquad (9)$$

Ura[18] has published tables from which values of the above parameter, corresponding to $\alpha = 0.05$ and $1 - \beta = 0.90$, can be obtained. Having obtained ϕ^2 for a value of n and k, the values of δ for each of the five types of slippages can be calculated. Thus the desired comparisons can be made. For n large and k equal to ten, the power to detect lack of control for the five types are 0.97, 0.92, 0.88, 0.63, and 0.54. For $k = 25$ the corresponding values are 0.99, 0.95, 0.93, 0.53, and 0.44. These values, of course, should be compared with 0.90, the value for the analysis of variance test.

The Control Chart for Ranges

In connection with a technical report[12] and in the preparation of his doctoral dissertation, R. W. Kennard investigated the properties of control charts for dispersion. This work, of course, included study of the control chart for ranges, no standard given. After careful analysis, he concluded that, in order to make any practical conclusions about a control chart using ranges, it seemed necessary to use experimental sampling. At that time, the amount of time available for experimental sampling was not great and the conclusions must be viewed as very tentative. From his work it seemed that α is small (practically zero for 3-sigma limits unless k exceeds 15) but that it increases with k, that the test has better power against the alternative of a single upward slippage than against general heterogeneity, and that this power increases with k. Also he thought that the test might not be robust and that non-normality rather than lack of control might sometimes be the cause of an indication of lack of control.

Table VI—Power of the Three-Sigma Limit Control Chart Test for Sample Means, No Standard Given, to Detect (a) Lack of Control, (b) the Single Slippage, when there is a Single Slippage of size $\delta\sigma$

	k = 10				k = 25			
	n = 5		n = 10		n = 5		n = 10	
δ	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
0.0	0.03		0.02		0.07		0.06	
0.5	0.05	0.02	0.07	0.05	0.09	0.03	0.12	0.07
1.0	0.19	0.16	0.45	0.44	0.25	0.20	0.54	0.51
1.5	0.52	0.51	0.90	0.61	0.61	0.59	0.94	0.94
2.0	0.85	0.85	1.00	1.00	0.91	0.90	1.00	1.00
2.5	0.98	0.98			0.99	0.99		
3.0	1.00	1.00			1.00	1.00		

Final Remarks

In the transition from phase one to phase two of the control operation, it is necessary to stop and establish standard values for the parameters. If the process is in a state of control and the test for control leads to the correct decision then parameters are estimated. If, on the basis of these estimates, the process is deemed to be satisfactory then it is a usual procedure to use these estimates as standard values. In (12), pp. 68-71, it was pointed out, if the process was in a state of control when the k samples were taken and if it remains in control when the $(k + 1)$st sample is taken, (i.e. the $k + 1$ samples are from the same normal universe), then the probability that the $(k + 1)$st sample falls within the control limits for sample means can be calculated by use of the t-distribution with $k(n - 1)$ degrees of freedom, if the control limits were based on a variance estimate obtained by pooling within-sample variances. If limits were based on mean range, then, as noted, the tables of Lord[8] can be used. Conversely, of course, the original limits can be set so that the probability is fixed at a desired level.

The above statements might serve as a veiled warning against setting standards on the basis of too few data. Such a warning may be necessary in view of the emphasis in some of the previous sections on the fact that an α of a desired size can be gotten from various (k, n) combinations by the proper choice of a, the sigma multiplier. As usual there is an upper limit on the value of a set of data. It is useful, however, to have some idea what that limit might be.

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A Quantitative Approach TO CLASSIFICATION OF CHARACTERISTICS

BENJAMIN W. MARGUGLIO

MARTIN W. SULLIVAN

Summary

WHEN GIVEN THE TASK of classifying characteristics within the framework of MIL-STD-105B or MIL-W-9411A, the engineer is confronted by a problem of "degree"—one which might be paraphrased as follows: "Doesn't any characteristic become critical if it is sufficiently defective or greatly out of tolerance?" The definitions for critical, major and minor characteristics established in the above listed documents, and most modifications thereof, are qualitative in nature and, therefore, do not afford the engineer an answer to the above question.

This article outlines a simple analytical procedure aimed at providing that quantitative solution necessary to economical decisions (at no sacrifice to quality) among the three classifications.

Introduction

"Quality" refers to the ability of the product to meet given specifications and comply with design drawings; specifically it refers to the consistency with which *all* items of the product meet design specifications. "Quality of a product" should not be confused with "a quality product," the latter having a generally accepted connotation of a luxury item.

The quality of a product can be measured only in

ASQC LCS Codes 213;223:60;70:400

This article was written at The Raytheon Co., Andover, Mass., by Benjamin W. Marguglio, who is now with The Martin Co., Baltimore, Md., and Martin W. Sullivan, The Raytheon Co., Andover, Mass.

relation to specified quality characteristics. By classifying the importance of each characteristic and inspecting to an adequate corresponding protection level, three substantial advantages accrue:

1. Quality is improved by affording each characteristic the proper inspection emphasis;
2. Inspection costs in relation to improved quality are reduced by de-emphasizing those characteristics of lesser importance;
3. Design is retained by the design agency. In the absence of classification of characteristics, each inspector is prone to accept or reject based on his own evaluation of the importance of the non-conforming characteristic, thereby altering the design criteria.

In most applications to costly, complex end products, characteristics are usually classified as follows:

1. *Critical—Very Serious*—a departure from requirements of such a characteristic, if undetected by inspection
   a. Could cause an operating failure of the system;
   b. Could result in reduced operating life of the system;
   c. Could cause personal injury or property damage.
2. *Major—Serious*—a departure from requirements of such a characteristic, if undetected by inspection
   a. Could cause a system failure of a less serious nature (e.g. adjustment failure, operation below standard);
   b. Could cause a failure of the unit (not of the system) or reduce the useability of the unit;
   c. Could affect interchangeability and assembly operations;
3. *Minor—Not Serious*—a departure from standards of such a characteristic, if undetected by inspection, although undesirable, would not appreciably interfere with the function or useability of the unit.

The Question of Degree

The above definitions are qualitative in nature. Conspicuously lacking is a quantitative guide to aid the classifier in his judgment. An obvious question from the design or cognizant engineer might be paraphrased as follows: "Doesn't any characteristic become critical if it is sufficiently defective or greatly out of tolerance?" Surely it is true that a four inch bolt could cause critical malfunction if it were eight inches long and thus interfered with a moving part, but the probability of such an occurrence not being detected by inspection is very slim under usual sampling protection levels.

The problem encountered by the engineer is therefore one of degree. Naturally, *if the engineer decides that a characteristic would be critical when its tolerance is exceeded, regardless of the degree, that characteristic should be classified as critical.* This situation does not present a problem. However, the engineer's dilemma arises when a characteristic can be either major or critical—major when its tolerance is exceeded by less than a specific amount, critical when its tolerance is exceeded by more than that specific amount.

Prone to think in terms of safety factors, the engineer would probably classify all such characteristics as critical, thus necessitating undue inspection emphasis and cost.

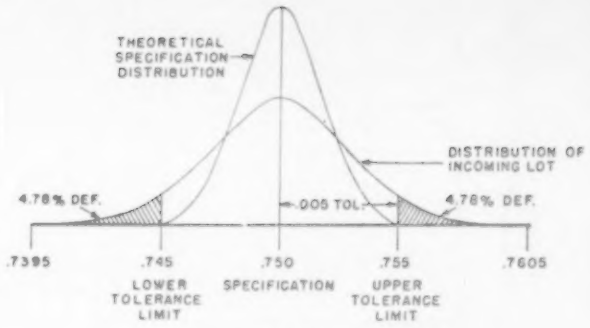


Figure 1—Incoming Lot Percent Defective

Analytical Decision Between Critical and Major Classification

An example would best illustrate the suggested quantitative approach to the above problem. Assume the following:

1. Incoming sampling inspection in accordance with MIL-STD-105B, Level II, Normal Inspection, 0.65 percent AQL
2. 100 percent inspection of rejected lots
3. An average incoming lot size of 100 units (necessitating a sample size of 25 with a rejection number of 1) with the characteristic in question classified as major
4. A drawing requirement for that characteristic of 0.750″ with a tolerance of ±0.005″ (0.745″ to 0.755″)
5. A normally distributed incoming lot of 100 units with this characteristic averaging 0.750″ and varying from 0.7395″ to 0.7605″—an excess of tolerance of approximately 110 percent determined as follows:

$$[(0.7605 - 0.755) \div 0.005]\ [100\%] = 110\%$$

Under this set of circumstances the estimated percent defective of the lot would be 9.56 percent, as shown in Fig. 1.

Standard deviation of incoming lot — estimated from range using seven sigma as representative of the distribution's total spread:*

$$\sigma' = (0.7605 - 0.7395)/7$$

$$\sigma' = 0.003$$

Percent of lot within tolerance (Q_t):

$$t = (0.750 - 0.745) \div 0.003 = +1.667$$ corresponding to 45.22%

$$t = (0.750 - 0.755) \div 0.003 = -1.667$$ corresponding to 45.22%

$$Q_t = 45.22\% + 45.22\% = 90.44\%$$

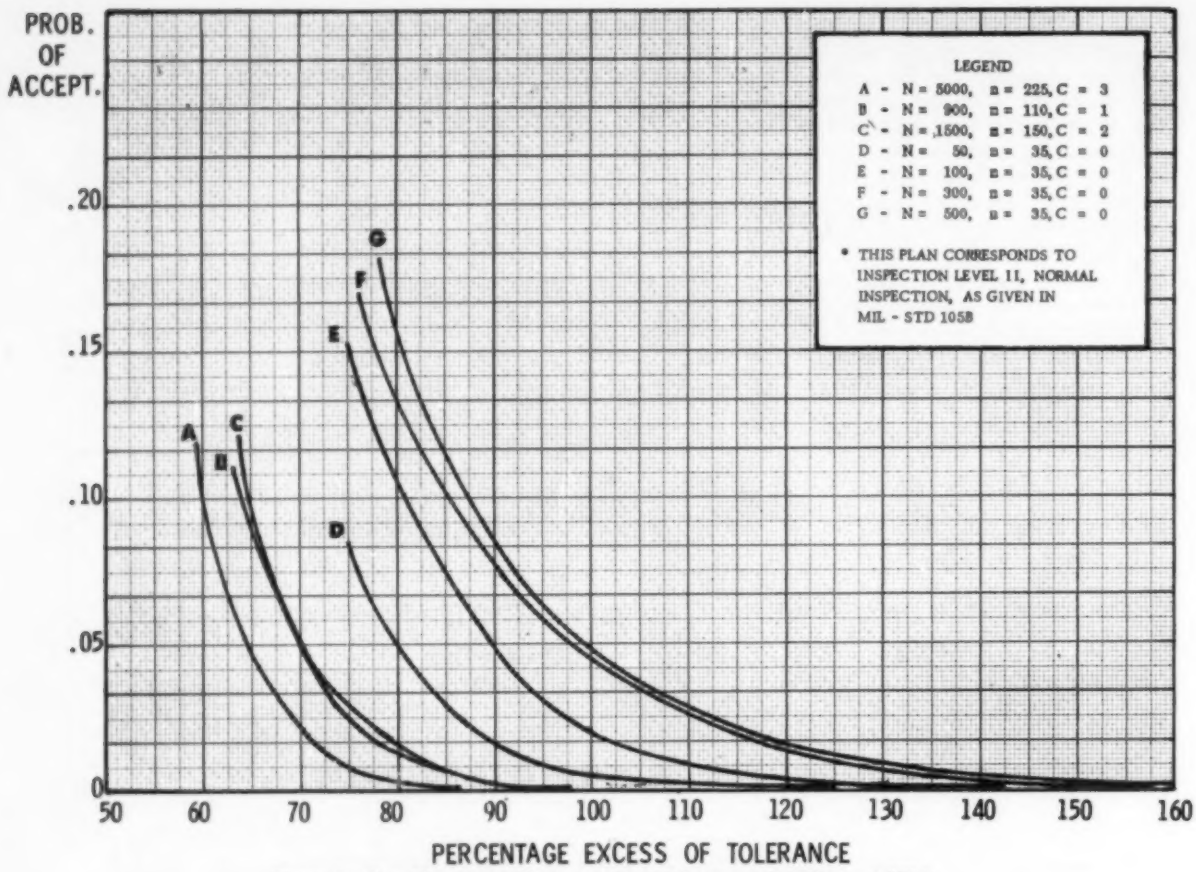
Percent of lot out of tolerance (P_t):

$$P_t = 100.00\% - 90.44\% = 9.56\%\dagger$$

The above assumed sampling plan would, for a 9.56 percent defective lot, yield a probability of re-

*The use of seven rather than six sigma to estimate the standard deviation results in a smaller estimate of the lot percent defective and, therefore, a smaller probability of rejection. This is a conservative approach in that the probability of rejection is more likely to be underestimated than overestimated.

†The estimated percent defective of the incoming lot is based on an equal proportion beyond each tolerance limit. If the distribution exhibited a mean shift, the percent defective would be greater and hence the probability of rejection would be greater.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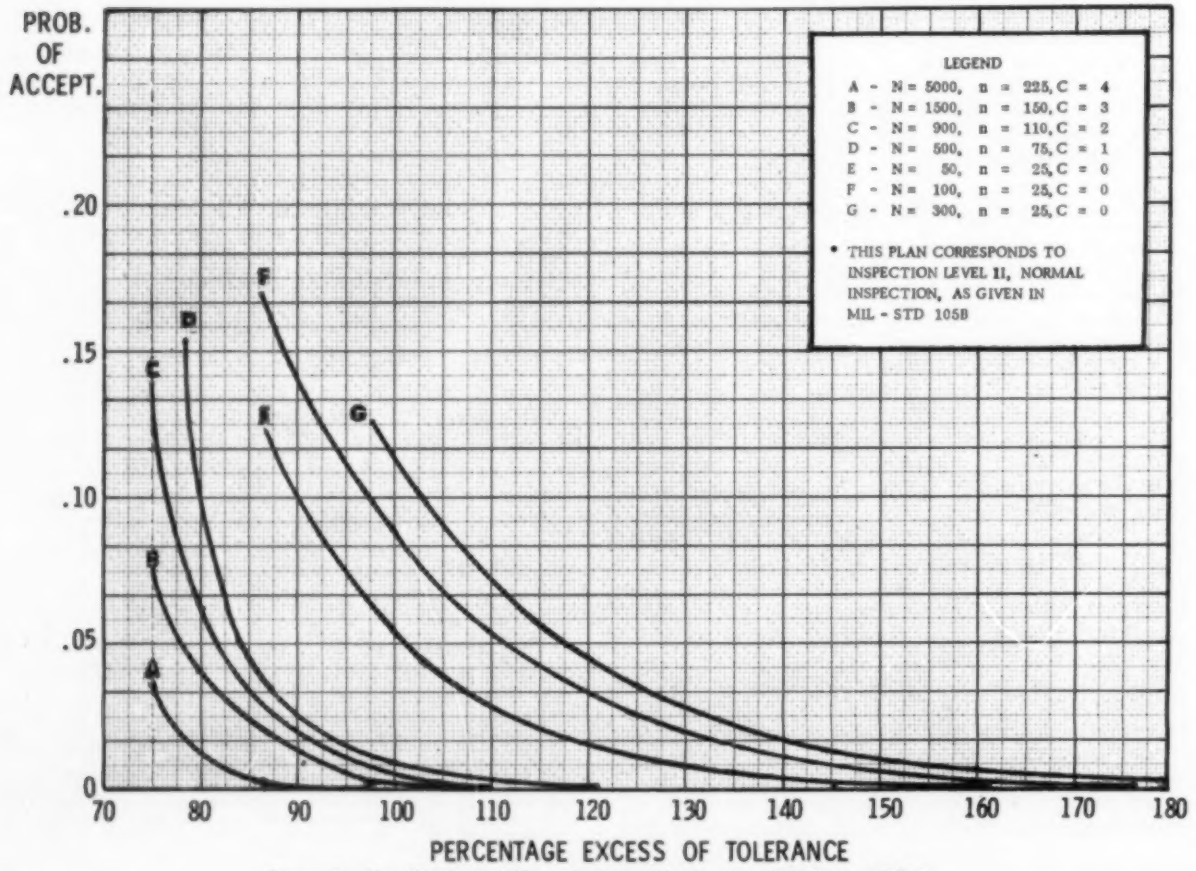
PERCENTAGE EXCESS OF TOLERANCE
LEGEND
A - N = 5000, n = 225, C = 3
B - N = 900, n = 110, C = 1
C - N = 1500, n = 150, C = 2
D - N = 50, n = 35, C = 0
E - N = 100, n = 35, C = 0
F - N = 300, n = 35, C = 0
G - N = 500, n = 35, C = 0
* THIS PLAN CORRESPONDS TO INSPECTION LEVEL II, NORMAL INSPECTION, AS GIVEN IN MIL - STD 105B

Figure 2—Classification of Charzcteristics Risk Curves, 0.40 Percent AQL*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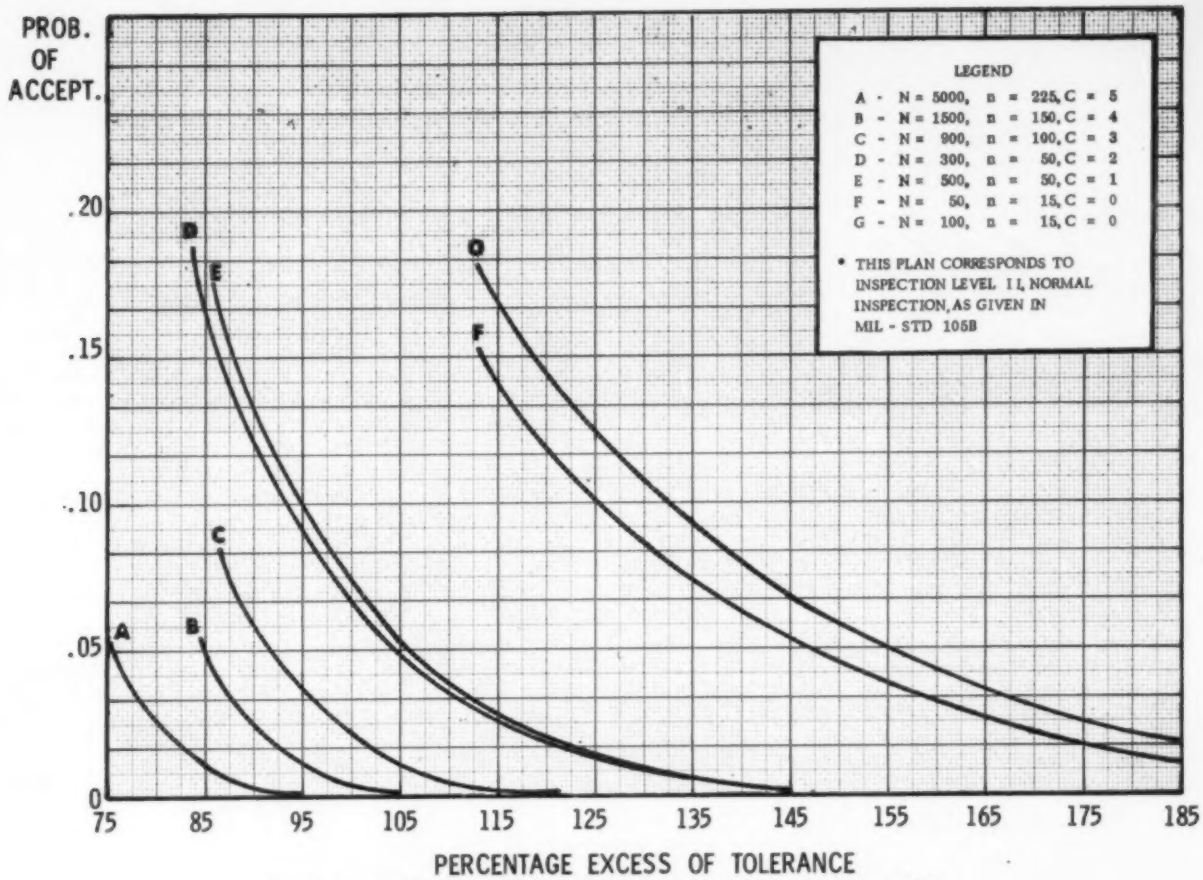
180
PERCENTAGE EXCESS OF TOLERANCE
LEGEND
A - N = 5000, n = 225, C = 4
B - N = 1500, n = 150, C = 3
C - N = 900, n = 110, C = 2
D - N = 500, n = 75, C = 1
E - N = 50, n = 25, C = 0
F - N = 100, n = 25, C = 0
G - N = 300, n = 25, C = 0
* THIS PLAN CORRESPONDS TO INSPECTION LEVEL II, NORMAL INSPECTION, AS GIVEN IN MIL - STD 105B

Figure 3—Classification of Characteristics Risk Curves, 0.65 Percent AQL*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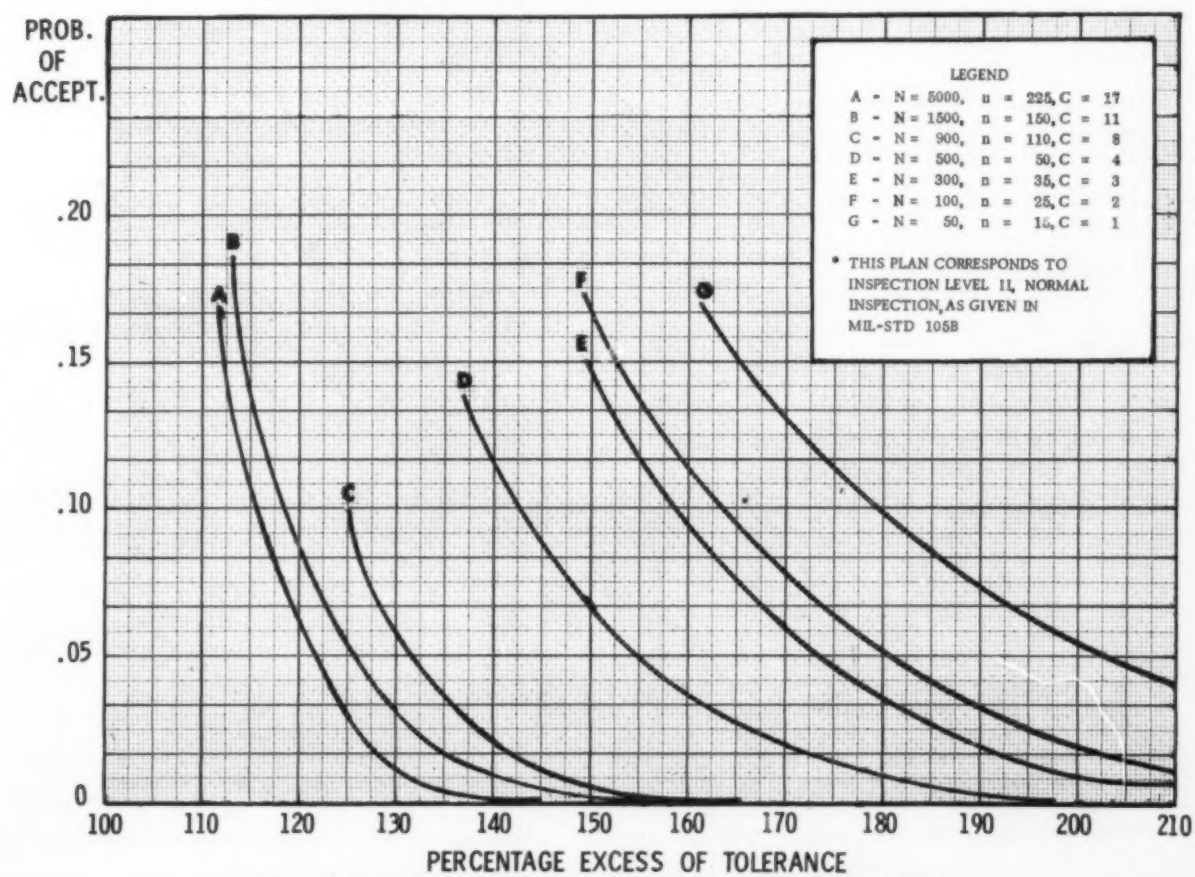
125
135
145
155
165
175
185
PERCENTAGE EXCESS OF TOLERANCE
LEGEND
A - N = 5000, n = 225, C = 5
B - N = 1500, n = 150, C = 4
C - N = 900, n = 100, C = 3
D - N = 300, n = 50, C = 2
E - N = 500, n = 50, C = 1
F - N = 50, n = 15, C = 0
G - N = 100, n = 15, C = 0
* THIS PLAN CORRESPONDS TO INSPECTION LEVEL I I, NORMAL INSPECTION, AS GIVEN IN MIL - STD 105B

Figure 4—Classification of Characteristics Risk Curves, 1.0 Percent AQL*


PROB. OF ACCEPT.
.20
.15
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0
100
110
120
130
140
150
160
170
180
190
200
210
PERCENTAGE EXCESS OF TOLERANCE
LEGEND
A - N = 5000, n = 225, C = 17
B - N = 1500, n = 150, C = 11
C - N = 900, n = 110, C = 8
D - N = 500, n = 50, C = 4
E - N = 300, n = 35, C = 3
F - N = 100, n = 25, C = 2
G - N = 50, n = 15, C = 1
* THIS PLAN CORRESPONDS TO INSPECTION LEVEL II, NORMAL INSPECTION, AS GIVEN IN MIL-STD 105B

Figure 5—Classification of Characteristics Risk Curves, 4.0 Percent AQL*

jection of approximately 0.952 as computed from the hypergeometric distribution.

Lastly, assume this 0.952 probability of rejection to be an adequate level of protection against accepting a critical departure from standards.

This simple analysis affords the engineer a quantitative tool to aid him in his decision between a critical and major characteristic. Applicable only to the above stated sampling plan, *if the engineer decides that a characteristic would be critical only when its tolerance is exceeded by 110 percent or more, that characteristic should be classified as major.*

Thus, for this sampling plan, if the characteristic were to exceed the drawing tolerance by anything greater than 110 percent, the lot would be greater than 9.56 percent defective and would, with very high probability, be rejected. All critical departures would be screened in 100 percent inspection. If the characteristic did not exceed the drawing tolerance by 110 percent or more it would not be critical by engineering decision and would be subject to the protection level for major characteristics provided by the sampling plan.

It must be stressed that the use of 110 percent in excess of the tolerance should not be considered as gospel. Rather, it signifies a protection level thought to be adequate by the engineer. The protection level offered by each percentage excess of the tolerance varies with different sampling plans as well as for different lot sizes within the same sampling plan.

In Figs. 2, 3, and 4, Classification of Characteristics Risk Curves are given for 0.40%, 0.65% and 1.0% AQL's respectively.

Again, an example best illustrates the use of these curves. Assume a 0.65% AQL sampling plan in existence for major characteristics with a minimum lot size of 100 for units in question. It is desired to determine that percentage excess of tolerance that will yield a 0.99 probability of rejecting the lot (0.01 probability of acceptance) that contains one or more critical deviations. A greater risk cannot be tolerated. From Fig. 3, curve F, 140 percent is found to meet the criteria. Therefore, in classifying characteristics, the engineer should:

1. Classify as critical those characteristics which will become critical when their tolerances are exceeded by less than 140 percent.
2. Classify as major those characteristics which will become critical only when their tolerances are exceeded by 140 percent or more.

Analytical Decision Between Major and Minor Classification

When a characteristic can be either minor or major —minor when its tolerance is exceeded by less than a specific amount, major when its tolerance is exceeded by more than that specific amount—a similar dilemma confronts the engineer. Using the applicable sampling plan for minor characteristics, the approach, as before, is merely to determine a percentage excess of tolerance that will yield a percent defective corresponding to the desired probability of rejecting a lot that contains one or more major deviations. Having determined this corresponding percentage excess of tolerance, the engineer would:

1. Classify as major those characteristics which will become major when their tolerances are exceeded by less than that determined percentage.
2. Classify as minor those characteristics which will become major only when their tolerances are exceeded by that determined percentage or more.

In Fig. 5, Classification of Characteristics Risk Curves are given for a 4.0 percent AQL which is very common sampling level for minor characteristics.

Conclusion

What has been done in this article can be summarized very simply. Percent defective has been converted to percentage excess of tolerance thereby converting operating characteristics curves to classification of characteristics risk curves.

To the authors' knowledge little, if anything, has ever been published on a statistical approach to classification of characteristics. The need exists for such an approach especially if industry is to meet realistically the increasing military requirements for classification of characteristics.

Granted, there are many uncontrollable factors such as differing engineering opinions, differing lot distributions and varying costs, to mention the more important ones. Nevertheless this technique provides estimates that are adequate for their purposes.

Reference

1. Brown, Dewitt and Sullivan, Martin; *Design Engineering Familiarization Presentation E.O.D. Quality Control Plan;* General Electric Co.; Cincinnati, Ohio; November, 1955; unpublished

Our Cover

Automatic Tester Selects And Displays Instructions

Engineer Stanley Mu completes a simulated diagnostic check of a guided missile on an automatic electronic analyzer that will predict the operational readiness of an intercontinental ballistic missile—or any other complex weapon system.

Developed by Hughes Aircraft Company and called D-PAT (for Drum-Programmed Automatic Tester), the new device uses a digital computer with test program procedures stored on a magnetic memory drum.

With its memory drum whirring at 2,300 revolutions a minute, D-PAT electronically clicks through a system checklist, confirming its own measurements with known values stored on the drum, and automatically starts exploring to investigate a suspected trouble spot. If a malfunction is detected that could cause an unsafe condition, D-PAT "declares an emergency" and automatically shuts down the system.

Then, dipping into its library of 35 mm slides, D-PAT flashes repair instructions on a 15-inch view screen, displaying a picture of the malfunctioning circuit or assembly with a bright red arrow spotted over the component that's causing the trouble and needs replacing.

D-PAT will also predict the remaining useful life of a component by comparing its operation with its past performance and with the manufacturer's specifications. If the component appears to be breaking down, it can be replaced before it causes a system failure.

VIDEOSONIC* SYSTEM INSTRUCTIONS RAISE QUALITY STANDARDS

Figure 1—Written planning, blueprints, parts lists, assembly instructions, etc., contribute to confusion and errors.

DAVID A. HILL, ***Semiconductor Division,***
JOHN J. TAMSEN, ***Communications Division, Engineering Laboratory, Hughes Aircraft Co.***

Human Error as One Cause of Failures

ANALYSIS of the basic causes of failure in electronic equipment points to human error as a problem. The nicked wire, the solder blob, the forgotten process control, the incomplete inspection, the bungled maintenance routine —we are all familiar with them. One of two things has happened. The human being at fault has not known what he needed to know or he has been careless or forgetful. Our stubborn tendency to do the wrong thing is summed up in the bitter phrase, "When all else fails, follow directions."

There are many opportunities for human weaknesses to affect otherwise satisfactory equipment. These range from the inadequate description of requirements to misuse of equipment after it is in operation. The techniques to be discussed appear particularly useful for, but are not limited to, the prevention of human error during:

- Manufacturing assembly operations
- Inspection and test
- Operations indoctrination and training
- Field checkout and maintenance
- Troubleshooting of malfunctions

Factors That Cause Errors

There are several factors which cause errors to result from human activity. Some factors for assembly operators and inspectors are:

- Remembering long lists of part numbers
- Identifying color coded parts accurately
- Tracking through complex wiring instructions and diagrams
- Carelessness with wire clippings, solder splashes, nuts, bolts, etc.
- Incomplete or inaccurate assembly and soldering practices
- Design change mental implementation
- Distracted attention while working

Other factors are important for test and troubleshooting. They are, in part:

- Long set-up and calibration routines
- Safety precautions (doing things in the right order to prevent damage)
- Numerous values and tolerances to check
- Remembering special techniques needed to diagnose troubles
- Losing track of specification changes

Attempts to Prevent or Diminish Human Error

Automation

The problem of human error can be tackled by taking the human out of the operation, as is attempted in automatic processing and testing. It will be some time before an automatic factory can handle the more complex assembly operations.

In electronics, the human being is likely to be a part of the production picture for quite some time. True, there are reports of methods for eliminating him — auto-assembly, deposited layers of film, monolithic circuit structures, etc. One needs only a moderately good memory to realize that hopeful announcements have been made at intervals for at least the last fifteen years. Like push-button warfare, this revolution is coming, but slowly. As for the operational and maintenance phase of an equipment's life, we must first accomplish fool-proof and perfectly reliable gear before human error is eliminated. A technique tailored to man's needs and weaknesses will have continuing use.

Improved Communications

Suppose we were to devise a system that would accomplish the following

- Provide complete instructions developed by experts and checked out by the most experienced workers
- Communicate these in the most easily understood forms
- Release the workers' hands so that their sole function is to perform work tasks
- And most important—give each instruction at the exact moment it is needed

Is it not reasonable to expect that a dramatic reduction in human error would result if there was such an improvement in communications?

A lack of adequate communication is one of the greatest barriers to accuracy, reliability and efficiency. It is most difficult for the highly skilled engineer to convey to the operator all the necessary information in simple, easily understood language via the medium of written planning. (See Fig. 1)

Ideally, we would have the engineer, the methods and quality experts, and the foreman sit with the individual production worker to guide him toward perfection. In recognition of this communications problem, Hughes established a special department to study and implement advanced manufacturing techniques. In the course of

ASQC LCS Code 352:70:000
*Videosonic—Trademark, Hughes Aircraft Co.

these studies, an entirely new concept in manufacturing systems was instituted. We call this new concept Videosonic system.

Videosonic system is the controlled visual flow of basic knowledge and experience through men, material and equipment. The Videosonic system is one of the most powerful tools ever developed for communicating intelligence in such a manner as to assure accuracy, guarantee standardization, and facilitate the understanding of the most complex data to individuals from all walks of life and of varying abilities. (See Fig. 2)

Equipment, Development

In recent years, we had used tape recorders alone as a means of communicating to our test technicians the sequenced test procedures and troubleshooting hints. This not only cut down on the time required for a test, but allowed for better utilization of manpower; test technicians could then be checked out on equipment in a fraction of the time necessary with printed procedures. Most important of all, hints on troubleshooting helped product reliability by reducing the number of trial and error parts-substitution, soldering and unsoldering of components, and number of on-cycles of the equipment under test. (See Fig. 3a)

While tape recording techniques were being developed for testing, the use of 35 mm colored slides showing parts location, color coding, examples of good quality in workmanship, etc., were being developed for use with printed step-by-step assembly instructions. (See Fig. 3b)

The marriage of the two, tapes and slides, for a single process in test, inspection and assembly was inevitable. The tapes communicated to the assembler, the inspector, and the test technician the sequenced procedure/instruction while the slides showed what the individual ought to see on scopes, meters, product, test positions, etc. However, while the commercially available slide projectors and tape recorders have been developed to a point of high efficiency, they are not wholly adequate for our needs. This led to the development at Hughes of special viewer-tape playback equipment designed for specific applications. We did continue to use the commercially available magazines for 35 mm slides and tape cartridges. The unit shown in Fig. 4 is one of the many types of audio-viewers developed by the several divisions of Hughes.

The Videosonic System

We next experimented to see just what the system would do for us. First, it required improved planning and programming which enabled us to break down into a series of discrete steps a process to be followed in a definite order. Normally, as more complex equipment was produced, more highly trained test and assembly personnel were required. The over-all Videosonics system enabled our company to use less highly trained personnel to a greater extent than would normally have been the case.

Second, pre-planning of fabrication functions was improved by the departments involved. Before the first article was produced, Quality Engineering, Test Engineering, Production Engineering, Methods and Time Study groups, line supervision, Planning, and quite important, the most experienced line workers participated in preparing audio-visual slide and tape packages to cover the step-by-step operations. (See Fig. 5) Note that this is done before the first article is made. The experienced workers cooperate fully to develop fabrication techniques, using shortcuts and assembly skills normally known only to the worker.

Third, there is an improvement in procedures and operations because this system captures, accumulates and retains technical know-how. Because of the system, technical know-how is arranged in appropriate combinations and is finally communicated specifically and sequentially at the proper time to each person performing a task. When once prepared, a presentation may be used on long or short run projects, may be set aside for long periods of time, and when needed again may be used without the long period of indoctrination normally required to retrain a worker.

We have noted many improvements due to the implementation of this system. They fall within four general areas:

- Reliability improvements
- Quality improvements
- Production improvements
- Improvements in employee relations

Detailed data and examples of the above improvements have been reserved for the section of this report entitled, "Benefits and Gains."

Specific Importance of Quality Engineering in This System

We have mentioned earlier that the worker uses the projected view from the slide as a method of comparison. It is important, therefore, that each slide be accurate not only of component location, but also as to workmanship detail. Certainly, a poorly dressed wire or a sloppily oriented part in conflict with the oral instructions could lead not only to confusion in the worker's mind, but could result in a continuous flow of defective parts. Therefore, before the slides are used or the tapes prepared, quality engineers review the scripts and scenes to assure that they meet quality standards. A special Quality Engineering approval stamp is placed upon each slide so that it is visible when viewed on the screen. Only approved slides may be used. This assures the worker that what she looks at is an approved view of the method and workmanship to be expected of her. The stamp appears under the cover of the Fidelipac cartridges for the tape recordings. Step by step visual inspections are built into the tape and slides as part of the production instructions.

Applications

Each of the fourteen operating activities within Hughes Aircraft Company has in some manner implemented the Videosonic System. The Falcon Missile at Tucson, Ariz., is assembled, inspected, tested, and supported in the field through this system. The Fire Control Systems manufactured at El Segundo are likewise supported and in addition the depot, operated by our Field Service and Support Division, uses it in repair, modification, and checkout. Experiments in our own Communications Division have been very successful. The various activities concerned with commercial products have implemented the system in these and other functions, such as process control, safety in handling chemicals, training, etc. and overall, the Research and Development Laboratories at Culver City have designed new equipment with this equipment installed to assist field

Figure 2—Production line workers using new Videosonic systems no longer require written planning and numerous written documents

Figure 3a—Early in the development of the Videosonic method, test procedures and trouble-shooting data were recorded to improve utilization, aid the test technician in locating problems, and improve product reliability

Figure 3b—An assembly work station with slide projection to indicate a view of the product which the assembler ought to see on the part she is assembling

Figure 4—A late model audio-viewer showing simple operating front panel control

operators in handling the more complex field checkout equipment.

There is no apparent end to the system's utilization. Our training departments, sales activities, employment departments, process control and fabrication operations, libraries, central document control areas, purchasing departments, and many others are currently using or are planning for future use of the system. One unique innovation, starting during the summer of 1959, was the taped instructions and slide views of forms for filling out employment questionnaires and security clearance applications; thus replacing a somewhat complicated instruction sheet.

In the area of customer use, the system boosts tactical readiness by supplementing the present technical capability levels of military support personnel. The system lessens the effect of personnel turnover. It assists in isolating and identifying authentic design or manufacturing deficiencies for effective corrective action, thereby accelerating squadron activation. Videosonic systems reduce military operating and maintenance costs.

Several months ago, a technical order was issued for the Falcon Missile. The complexity both in number and type of changes caused no end of confusion. A special team was sent to the depot to assist. This helped for a while. On a chance that audio-visual instructions might be the answer, a special package was prepared on this difficult T.O. and sent to the depot with an audio-viewer. The special team from Hughes tried it out successfully and when ready to let the Air Force experienced technician attempt the task, learned that he was in the hospital. Another technician was selected, one who had no knowledge of the Technical Order, and on his first attempt using Videosonics, accomplished the task in far less time than the experienced technician did without the benefit of the special package. This emergency answer to a need has resulted in the complete utilization of the equipment for the balance of the Technical Order and for others to follow.

Benefits and Gains Which We Have Experienced

The benefits and gains realized since the implementation of the

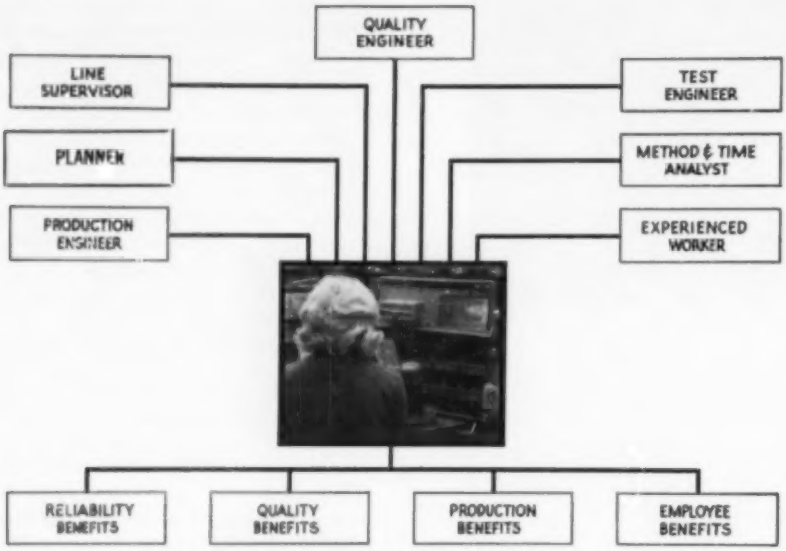


Figure 5—Components of Videosonic System

Videosonic system have fallen into four basic groups. They are:

Reliability benefits
Quality benefits
Production benefits
Employee relations benefits

Many of the benefits will overlap between groups. However, for convenience in discussion, we will observe them as associated with but one group. Let us look at these benefits in the above order.

Reliability Benefits

We have discovered through continuous sampling and statistical evaluation that reliability, especially in the Falcon Missile, is dependent upon a unit's first acceptance through test. Components which fail when first tested generally require rework. During rework, parts must be unsoldered, removed, and new parts resoldered. Such resoldering weakens the printed circuits and adjoining connections to such an extent that the probability of a subsequent failure is increased. Audio-visual instructions have provided a method for improving workmanship. As a result fewer defects are noted during test which are traceable to workmanship faults.

Before this system was applied, between 50 to 60 percent of all electronic packages submitted passed their first test successfully.

After application, between 75 and 85 percent passed their first test.

On the most complex chassis in the Falcon Missile, rarely did better than 50 percent pass the first test. After application, the rate had increased to an average of 84 percent. An exhaustive evaluation was made of this improvement. All squawks were analyzed and assigned as either a component failure or a workmanship defect. Component failures were defined as parts which failed because of hidden defects or inherent faults which were destined to show up regardless of the care exercised by the worker. Workmanship defects include all faults in wiring, soldering, installation, and any other problem built into the units during assembly at Hughes. The final analysis before, after and during the implementation of the Videosonic system, is shown graphically in Fig. 6.

Component failures have remained relatively constant throughout the control period. Workmanship defects have shown a rapid decrease during the period of implementation and have leveled out to a point which is well within any calculable control limits. As a result, we have generalized a theory that if a unit will not pass its first test the fault lies with a component part. Each failure is carefully analyzed in order to increase the reliability by procuring better parts or helping our suppliers build more reliable components.

Other divisions of the company are experiencing similar results. For example, on our Fire Control Systems the average test defect per unit rate has decreased from 1.64 to 0.28. The decrease in defect rates is further reflected in an average savings in test time of

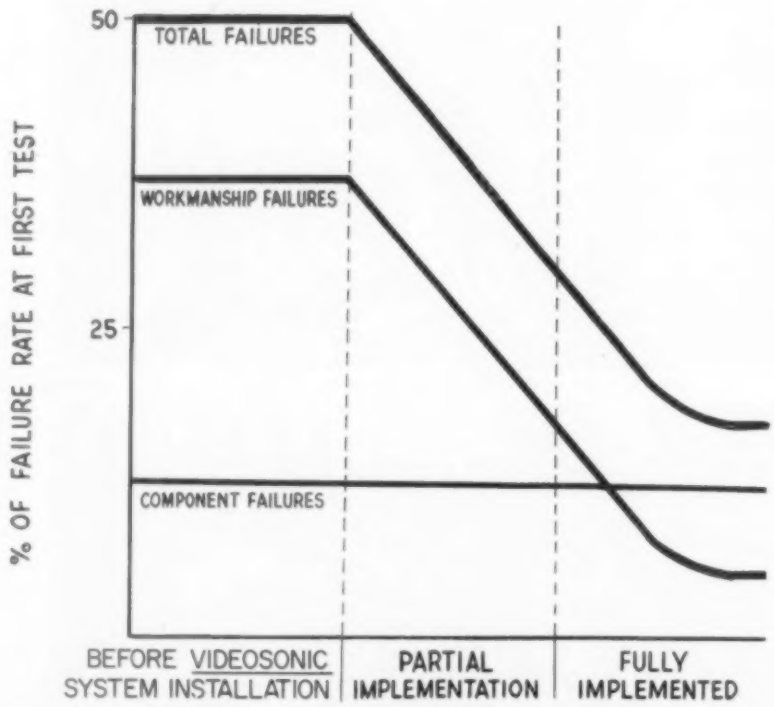


Figure 6—Chart showing relation of causes of failure discovered during first test of electronic components in Falcon Missile.

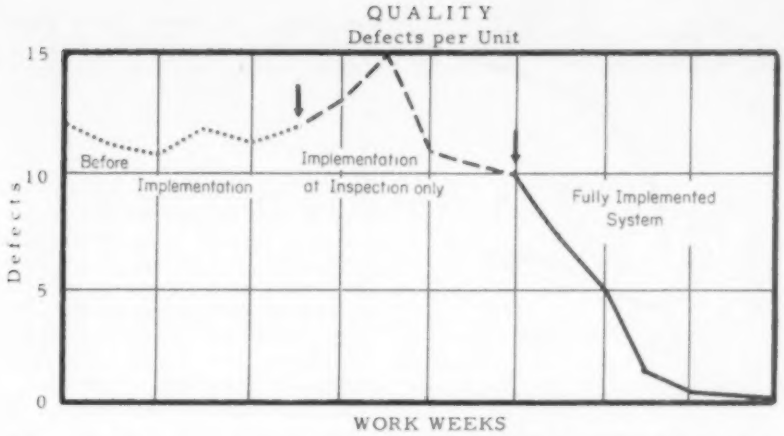


Figure 7—This chart shows the trends recorded in the reduction of defects before, during implementation, and after installing the Videosonic system assembly and inspection, as recorded at inspection.

about our hour, 30 minutes per unit. On one unit, formerly having the highest defect rate, the average test defects per unit fell from 5.02 to 1.50.

Quality Benefits

Our quality benefits are measured in terms of reductions in defects per unit or per standard hour as recorded by inspection. The Videosonic system has established a standard approach in assembly. *The assembler sees the location of parts, the routing of wires, etc., in color exactly as they should appear on the assembled part.* They hear and see that the black band of a capacitor is on the right. They hear and see that the red wire goes to point X and the yellow wire goes to point Y. As indicated in the section above on reliability, reversed wires and incorrectly oriented parts seldom occur. With this system at inspection, the inspector is told to look for certain parts and wires and their relation to others. They also see, for comparison, the colored slide and the part which is being inspected. This combination of activity — at assembly and inspection — has resulted in an average defect per unit rate decrease from 1.2 to 0.115, less than ten percent of the former rate. On one unit with 347 solder connections, about 150 parts, and with a 21 wire harness the average defects before the Videosonic system was 0.6 per unit. After application, and during the entire period to date, there has not been one single workmanship squawk recorded.

Figure 7 shows the graphical relation of defects before, after, and during the initial implementation. The sharp rise noted during the period when inspection first used this system is indicative of the more thorough inspection which discovered defects normally found during test, or not discovered at all. When once located, concentrated efforts were made to eliminate recurrent defects by planning corrective action in assembly presentations.

Production Benefits

Production benefits are best shown in the improved utilization of the available manpower. We were operating before Videosonic system installation at a rate of 47 percent. The average utilization today on 25 different manufactured items is 90 percent. A typical assembly line at our Tucson facility, formerly had seven assemblers, one rotating substitute assembler for absences, one rework assembler, one checker to review the items before inspection, and one and one-half inspectors. After installing this system, the checker was deleted, there was no need for the substitute assembler, and because of the vast decrease in defects, the rework assembler could not be utilized full time, and the inspector dropped to one-half. Also, of significance, the number of assemblers required to produce the same number of items fell from seven to five. Fig. 8 shows the steady climb in utilization rates for the several units.

Employee Relations

There is an increase in the general morale with a more desirable attitude expressed by the individual employee. Direct measurement within this area is difficult to obtain, if not impossible. However, in general we have noted a decline in the absence rate of female employees, a marked increase in the number of new hires who stay over a longer period (a reflection of a decreasing turnover rate), etc. Of particular importance is the quality measurements of individual worker performance. Formerly, an assembly line as a whole was measured. After the Videosonic system was applied, each assembler was individually measured for quality performance; an advantageous feature of this system makes this possible. Now workers with like abilities and speed can be relocated to advantage, that is, take slow workers from a fast moving line and replace them with faster workers so that the line may move at a constant speed. Through an extensive quality indoctrination program, the line assemblers have accepted the individual measurement plan and strive to improve their own records. We do not use this plan as a lever through which the worker is forced to do better or else. Rather it is a motivation

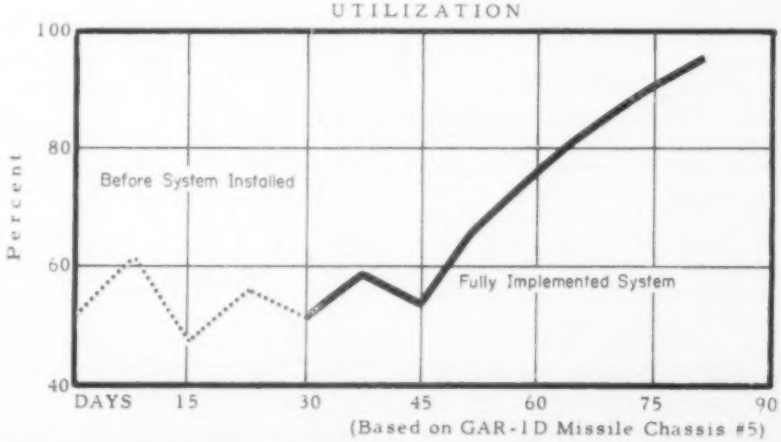


Figure 8—This chart shows the steady rise in the utilization rate experienced due to the implementation of the Videosonic system

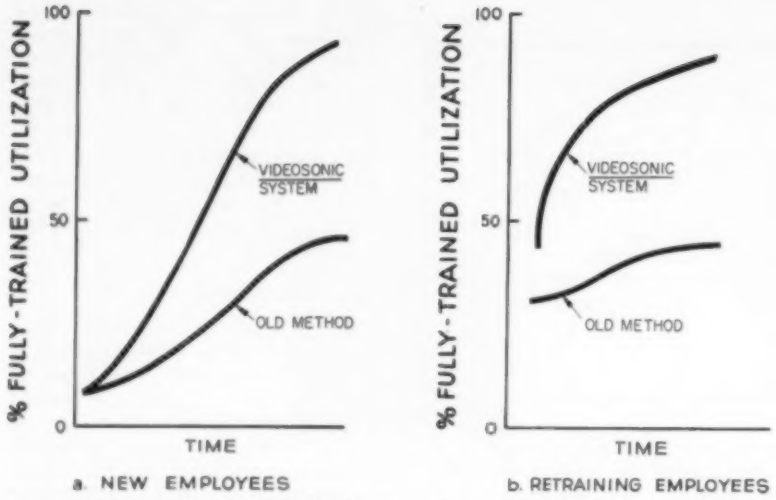


Figure 9—Relative improvements in learning curves for a. New employees and b. Relocated employees new to the function.

to build pride in workmanship, a pride which the worker feels is important in his work.

The learning curve in training or retraining is a function of the time taken to become proficient enough to do productive labor at a point equal to or slightly less than that of the average production worker. The learning curve under this system has gone up rapidly. New employees are reaching a point through the use of this system in less than half the time formerly required, and within the same time are nearly twice as proficient. Employees are relocated on new assignments with but one day's practice and on the second day are as proficient as the regular workers. Normally, a relocated worker would require about two weeks for the same results. Fig. 9 shows various relations in learning time.

Cost Savings

Extensive reports are being made upon the results of production using the Videosonic system. One study, comprehensive in nature, deals with costs expended and costs saved. In fact, every cost within the factory and administrative applications is recorded. The crossover point came in the third year. During the following years the savings exceeded the cumulative cost of Videosonic systems. Fig. 10 shows first the crossover point and the relative points of cost savings and expenditures, and the components of costs at the point of crossover.

Summary

In this article we have told of our experiences. We saw how human error in assembly, inspection and test is one of the greatest causes of failures in electronic equipment. Human error can, to a certain degree, be eliminated by automation. However, certain functions require the exercise of the human mind and hands. To these functions a better means of communication was the answer. One method devised at Hughes was the audio-visual means of communication, which when fully implemented became what we call the Videosonic system. This is a means of controlling the visual flow of basic knowledge and experience through men, material and equipment. In order to fulfill the need of this philosophy, we had to develop new manufacturing methods and special equipment. The equipment was designed so that the worker had merely to turn it on and proceed to work without having to remove her hands from the tools or item being made. The equipment was fully automatic.

We have applied this method at assembly, inspection and test. We also have used the equipment in other non-productive areas, such as employment, training, record keeping, sales, retention of process techniques, and so on.

Figure 5 indicated the components of input and output of the system. The outputs of the system are in reality the areas where benefits have accrued. We noted them as being reliability, quality, production and employee relations. The costs incurred in the implementation of the system have exceeded the cost savings during the early phases but a crossover point was seen in the third year of operation, and from then on the savings have exceeded the cumulative expenses each year.

The Videosonic system has improved communications, reduced our costs, improved the ability of our company to move quickly to new market situations, and has greatly improved the reliability and quality of our products.

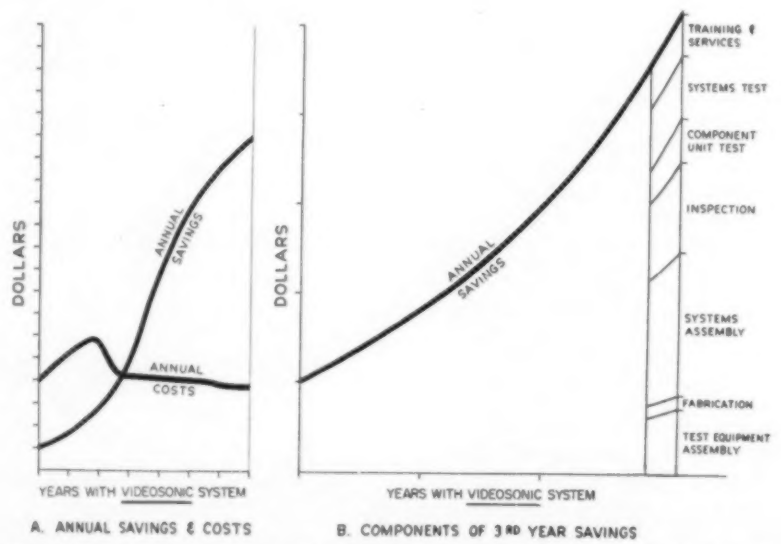


Figure 10—a. Crossover between costs saved and costs expended. b. Components of costs saved at point of crossover.

RELIABILITY

Both a Tool And Objective In Design

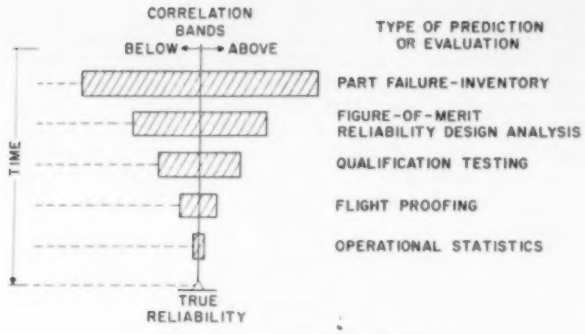


Figure 1—Evolution of True Reliability

S. N. GREENBERG and S. ZWERLING

Missile and Space Vehicle Department, General Electric Co., Philadelphia, Pa.

RELIABILITY is an attribute of a product. It is measured, however, only when the product is put to use. We may test each of its constituents under all conditions it will experience as a part of the completed product; but because of the interaction of the elements, through the complexity of combination, the probability of the device to operate in totality remains unknown. Thus, we can see that although a system is composed of many components in individual subsystems, only their composite in the specific mission and environment defines the reliability. The design engineer is responsible, at the lowest component level, to produce a unit which, when taken alone, has no ascribable reliability. When operated as required in its actual environment and in its scheduled and specified manner, its effectiveness in meeting these conditions is then measured as a reliability parameter of that component.

In today's space age many missile flights are aborted by failures of an extremely minute and subtle nature which have been disclosed through diagnostic data, and the majority of these are attributable to the design. In order to be effective in anticipating or detecting the probability of failure early enough in the development of the component to remedy the design, a great deal of attention must be paid to the reliability of the component from the earliest design stage. The point which is now becoming more and more deeply impressed on the design engineer is that he must design reliability into the product. He has not been trained specifically as a reliability engineer, and only recently has he become heavily aware of the importance of adding the reliability characteristic into the design. In the past he concentrated on only the characteristics of performance, maintainability, and producibility. We must indoctrinate him with an understanding to recognize that reliability is also a major characteristic of design.

What can we do for the design engineer to assure ourselves that he is equipped to provide a reliable component?

At MSVD we are attempting to provide each design engineer with necessary instruction in the field of reliable design practices and techniques. He is supplied the necessary reliability design analysis manuals and application data to be used in performing his own analysis and thus appreciates the reliability attainment of his design.

The design engineer conducts an initial reliability figure of merit analysis on his design and re-evaluates it periodically as changes or design alternatives are presented.

The Reliability Figure of Merit (RFM) is a value, derived through analytical methods, which expresses the probability that the component or system under design will give a performance without failure for the required length of time and in the manner and environments in which it is to operate. This value is based on a scale of zero to 1.00.

Reliability Figure of Merit Analysis is used to evaluate a design through all the design stages and provides a means of optimizing a single design during the course of its development or in serving as a basis of comparison or selection among competing designs. An equally interesting characteristic of this figure of merit value is that it may be employed as some limited measure of attainment of the final reliability goal for the design. This may be seen in Fig. 1.

The limitation we must place on accepting a reliability figure of merit as a product predictor for reliability is exemplified in Fig. 1. Use of reliability or failure rate data on component parts to predict the over-all mission reliability provides only very broadband results when subjected to an analysis. This is due to the uncertainty and the inaccuracy of the

ASQC LCS Code 830:60:436

specific failure rate information available for parts, as well as to the interaction of the parts which creates new environments within the equipment physical confines. The narrowing of this data band may be accomplished by using modified techniques or reliability information on higher levels of assembly.

The basic approach to our analysis is made from a part failure rate point of view, keeping in mind its wide-band validity. To further narrow that band into having meaning in our design analysis, we consider the actual application and function of the part as it is employed in the circuit. It has been shown that analysis conducted from a functional, operation-oriented approach not only improves the validity of the results but serves as an important tool toward reliability design improvement. The approach of treating an equipment as a "box full of parts" and merely inventorying the part failure rates is thereby circumvented.

CAPACITORS
PART USAGE AND APPLICATION DATA

Component Name_____ Wiring Diagram_____

Ass'y. Dwg. No._____ Schematic Diagram_____

Circuit Symbol No.	Class(Mica, Glass,etc.)	Type & Vendor MIL Designation or GE Designat.	Value MFD	Rated Voltage	Operating Voltage	% Rated Voltage	Operating Ambient Temp.	Failure Rate %/1000 hrs.

CONNECTORS

Circuit Symbol No.	Connector Type	Type & Vendor MIL Designation or GE Designation	No. of Pins	No. of Pins Used	Failure Rate %/1000 hrs.

ELECTRON TUBES

Ckt. Symb. No.	Tube Class	Type & Vendor MIL Designation or GE Designat.	Rated Heater Voltage	Heater Voltage Used	% Rated Heater Voltage	Max Rated Watts	Total Wattage Used	% Rated Wattage Used	Oper. Ambient Temp.	Failure Rate %/1000 h

MISCELLANEOUS PARTS

Circuit Symbol No.	Component Part	Type & Vendor MIL Designation or GE Designation	Failure Rate %/1000 hrs.

MOTORS

Circuit Symbol No.	Type & Vendor MIL Designation or GE Designation	Class of Insulation	Operating Temperature	Operating Ambient Temp.	Temperature Rise	Motor Speed RPM	Failure Rate %/1000 hrs.

RELAYS

Ckt. Symb. No.	Relay Class	Type & Vendor MIL Designation or GE Designation	Contact Current Rating	Oper. Contact Current	Activ-ations per hr	% Rated Currents	Contact Set F/R	Operating Ambient Temp.	Failure Rate %/1000 h

Figure 2—Part Usage and Application Data Forms—Part I

Reliability Figure of Merit Analysis

The procedure for performing a figure of merit analysis for the reliability of a component, subsystem, or system is described in a MSVD reliability design analysis manual. Based on a thorough understanding of the concepts and principles discussed in the manual, the design engineer may utilize the step-by-step procedures listed below and as illustrated by the sample analyses.

1. List all of the component parts on the Part Usage and Application Data forms similar to those shown on Fig. 2 and complete all the information requested for the particular part.

2. To provide information for the last column of these forms, namely "Failure Rate %/1000 hours" a reliability analysis data handbook is employed. Failure rates are obtained by evaluating the component part under the operational stresses and circuit loads which it experiences. Failure rate *vs.* stress curves, as illustrated in Fig. 3, are provided in this handbook for most electrical and electromechanical parts.

3. Determine, from the circuit arrangement of components, the number of parts in redundancy; and employ the mathematical techniques provided in the Reliability Design Analysis Manual to compute the combined probabilities of failure.

4. Total the failure rates in %/1000 hours for each circuit as follows:

$$\lambda \text{ (circuit)} = \lambda \text{ (part one)} + \lambda \text{ (part two)} + \cdots + \lambda \text{ (part n)}$$

5. Assess the contribution of the circuit to the functional efficiency of the component and apply a weighting factor to the λ(circuit) in 4 above to reflect the level of importance of the circuit to the over-all mission effectiveness. The design engineer is cautioned relative to this concept and should seek the assistance of reliability consultants in its use.

6. Total the failure rates of all the circuits and all associated time-affected parts and convert to a reliability value based on the operational duty cycle time, t.

$$P_s = e^{-\lambda_{TOTAL} t}$$

where

λ_{TOTAL} is the failure rate in %/1000 hours

P_s is the probability of survival or reliability

7. When "exclusively" operating or "one-shot" devices such as squibs, detonators, explosive switches, *etc,* are used; provide reliability values in terms of probability of successful operation and combine product-wise with the reliability values, P_s, in 6 above to give the component Reliability Figure of Merit, RFM, for the required operating time.

$$RFM = P_{s1} \cdot P_{s2} \cdot P_{s3} \cdot \cdots \cdot P_{sn}$$

where

P_{s1}, P_{s2}, and P_{s3} are the probabilities of successful operation.

The order of the steps in the procedure described is generally useful in most electrical and electronic circuit analyses for reliability figure of merit. Because of the variety of circumstances for circuit employment, no idealized sample reliability figure of merit analysis is possible. Actual reliability figure of merit analyses are furnished to the design engineer as illustrative material applicable to a better understanding of the analysis.

In the Step 1 above, improper selection of parts can be disclosed and indications of their suitability to the application may be determined. In Step 2, the assignment of the failure rate to the particular part again may be the basis for determining any misapplication, heavy loading, or high-failure-rate potential of the parts. At this point the design engineer may decide on suitable trade-offs to alleviate the prob-

lems presented through various reliability improvement techniques such as:

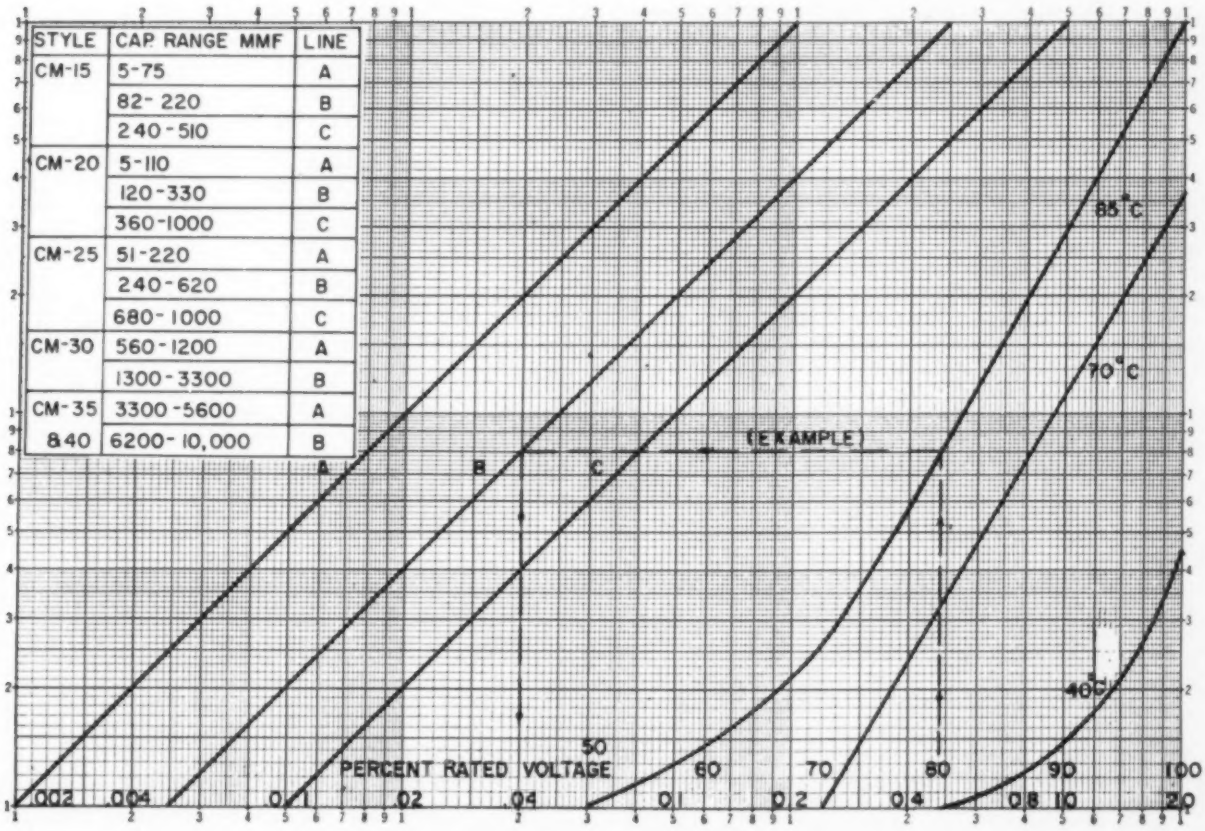
1. Derating in parts application: applying adequate margins of safety for the stresses.
2. Substitution for notoriously high-failure-rate parts with lower failure probability.
3. Circuit redesign.
4. Environmental isolation by shock mounts, heat-sinks, acoustic insulation, and thermally controlled chambers; encapsulation and embedment; etc.
5. Redundancy techniques, where applicable and where circuit parameters are not compromised.
6. Wide tolerance circuitry growing out of "worst case" random-balance design[1] or part-value-variations[2] design.

To determine the operating time of the part in the actual mission, the duty cycle must be known or closely approximated. Methods for computing the expected failures for the parts are provided for use by the design engineer in his analysis.

The arrangement of components or parts is considered in Step 3. In the series or interdependent arrangement of parts, an addition process for the expected failures is performed; the reliability is the negative exponential of the sum of such values, assuming a random distribution of failures. The redundant elements are evaluated for their number of expected failures by applicable redundancy computational processes, resulting in a value for the probability of any one of the element group to survive the mission.

Where failure modes are mainly "short," redundancy is in the form of a series arrangement of the elements; where the mode of failure is "open," the redundancy provision is for elements in parallel. Changes in circuit parameters are effected by redundant use of electronic parts; therefore, circuit operational tolerance rules must be obeyed when employing these techniques. The failure of one element of a redundant group may degrade the circuit operation so far from specification that the fault must be classified as a catastrophic or vital failure of the component.

A reliability block diagram for components, subsystems, and systems normally serves to define the basis for the development of a reliability mathematical model which will permit us to perform the necessary calculations. Figure 4 is an illustration of a subsystem in block diagram form and the mathematical model which was derived from it. Although Step 6 is not normally performed on parts at the component level, the effectiveness of the failure of a part in contributing to the catastrophic failure of the subsystem or system must be considered. A part that fails in a sensor circuit for a telemeter data transmission link, although degrading to the single circuit, may merely cause the loss of a minor piece of information. The information may otherwise be interpreted from alternate channel sensing circuits. Thus, a weighting factor may be applied to compensate for these deviations. Where more than one mode of failure is attributable to a single part, the individual



FAILURE RATE (% / 1000 hours)

Figure 3—Failure Rates for Molded Mica Capacitors (MIL-C-5)

probabilities of the modes are estimated from the general part failure rate and prorated in such a manner as to reflect the duty cycle of the part under the various modes with respect to the mission.

All failure rates upon which the curves are based were evaluated to a 90 percent confidence level. The figure of merit derived from these computations, therefore, must be expected to have a confidence level at least as great as 90 percent. E. Fritz* shows the probability of confidence as great as 99 percent with the combinational effect of as few as ten elements whose individual failure rate values have been determined to a 90 percent confidence level. If we consider that each confidence to a 90 percent level is a conservative estimate at best, then, for a larger number of elements, such conservatism becomes more pronounced. The figure of merit value obtained is the basic value upon which the design engineer will (1) adjudge the effectiveness of his design, (2) select among two or more designs through comparison of values similarly obtained for the various designs, and (3) evaluate his progress in attaining the apportioned value assigned his component as part of the system function.

Apportionment of Reliability

Reliability is apportioned to the individual systems, subsystems, and components of the weapons complex in order to establish the minimum acceptable reliability levels for each design which will permit us to meet the over-all reliability requirement. Many contracts are now being drawn up containing specific reliability levels whose feasibility of attainment must be demonstrated by the contractor before the design will be accepted by the customer. An apportionment exercise may be performed somewhat as follows, understanding of course that the simplicity of the presentation is quite exaggerated.

Initial Apportionment

The system conceptual design is first described in the form of functional block diagrams of subsystems. The subsystem requirements are then identified, and components which are to perform the subsystem tasks are summarily selected or invented. The process is not intricate, as there are various landmarks for the selection of components to perform a specific task. Experience gained through analogous application in former programs and projects may provide the basis for a solution to the problem.

1. The total number of allowable failures, $(\lambda t)_a$, for the system being apportioned is obtained from the contracted reliability, R_a, as follows:

$$R_a = e^{-(\lambda t)_a}$$

$$(\lambda t)_a = -\ln R_a$$

where

λ = system failure rate

$t = 1$ (time normalized for mission)

For our example, a 90 percent reliability is required to a stated confidence level; thus, to determine the $(\lambda t)_a$:

$-\ln 0.900 = (\lambda t)_a = 0.105$ failures for mission

2. The components in the subsystems are further analyzed and a complexity evaluation is performed. The number of active elements, E (i.e., electron tubes, transistors, rectifiers, diodes, relays, etc.) is determined or estimated. These are tabulated for each subsystem (or component) in Table I, and $(\lambda t)_a$ failures

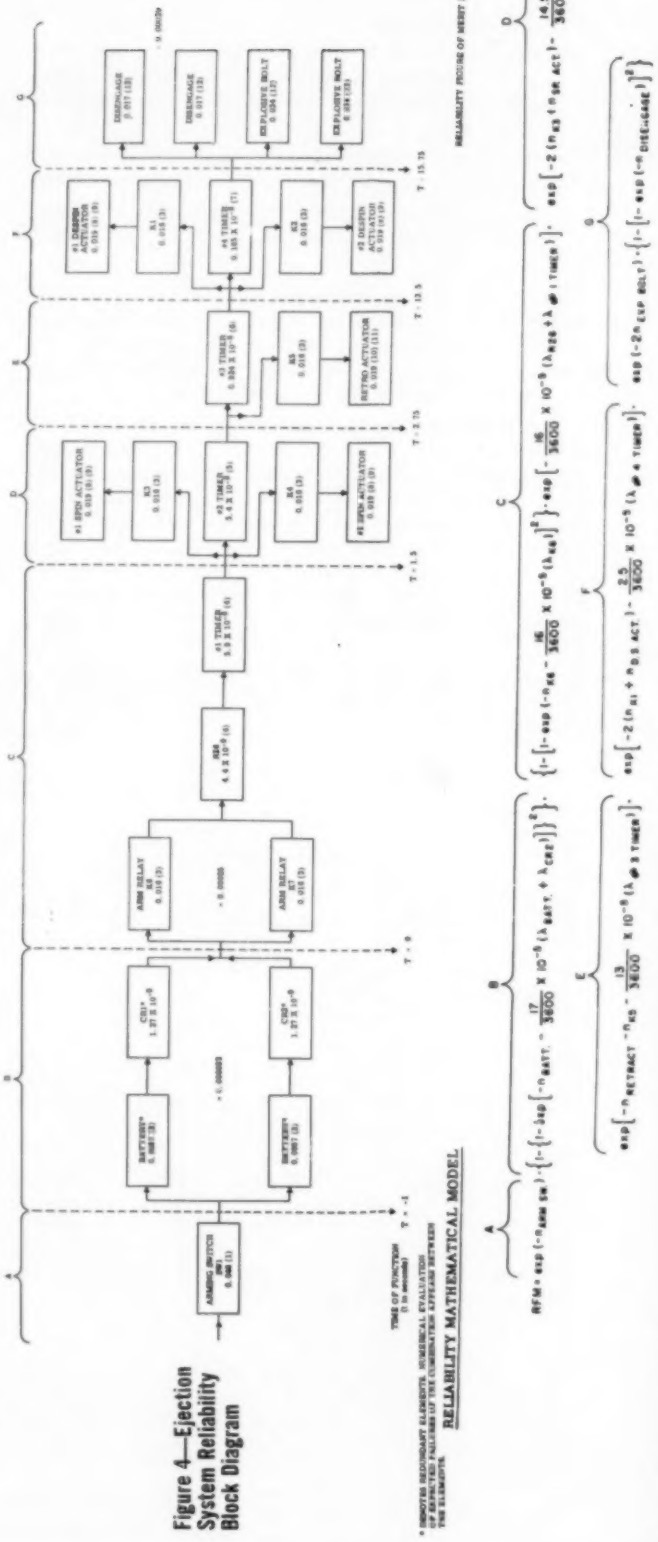


Figure 4—Ejection System Reliability Block Diagram

*Work under way at MSVD.

Table I—Apportionment by Complexity

Equipment	E Complexity or No. Active Elements	$(\lambda t)_x = \frac{E}{\Sigma E}(\lambda t)_a$	RELIABILITY $R_x(x) = e^{-(\lambda t)_x}$
Subsystem A	17	$\frac{17}{52} \times 0.105 = 0.0342$	$R_x(A) = 0.9664$
Subsystem B	15	$\frac{15}{52} \times 0.105 = 0.0304$	$R_x(B) = 0.9701$
Subsystem C	20	$\frac{20}{52} \times 0.105 = 0.0403$	$R_x(C) = 0.9605$
System	$\Sigma E = 52$	$\Sigma(\lambda t)_x = 0.1049$	$R_s = \prod_{x=a}^{c} R_x(x) = 0.9004$

per mission are apportioned in accordance with the relative complexity of the subsystem (component), $E/\Sigma E$.

Subsystems A, B, and C have had the system reliability suballocated to them on seemingly the most equitable basis, namely their complexity. This value may be used in feasibility studies concerned with the actual design of the subsystems and components.

Figure of Merit Analyses

Reliability design analyses are performed on all components and subsystems as described earlier in this article, and the reports produced are consolidated and reliability values tabulated and tallied. This is a second cut; and the original problem of determining the complexity is no longer present, as this factor is accounted for through a figure of merit analysis.

The number of system failures estimated through reported analyses values $(\lambda t)_r$ is determined in Table II.

The values of reliability as reported may make it appear that "Subsystem A" with 0.963 has almost met his apportioned value (0.9664 of Table I). "Subsystem C" appears to have exceeded his apportioned

Table II—Reported Values from RFM Analyses

Subsystem A	$R_r(A) = 0.963$	$-\ln R_r(A) = 0.0377$
Subsystem B	$R_r(B) = 0.931$	$-\ln R_r(B) = 0.0715$
Subsystem C	$R_r(C) = 0.970$	$-\ln R_r(C) = 0.0305$
System	$R_r = 0.8696$	$(\lambda t)_r = 0.1397$

0.9605, but "Subsystem B" is sadly short of its quota. So, on this "go around," it appears that adjustment takes place which re-establishes equitability. This is accomplished through reapportionment by a process very similar to the parimutuel technique for tabulating and computing betting odds and pay-offs at race tracks.

Reapportionment

The expression used for computing reapportionment of the subsystems as reported in Table II is:

$$R_{2a}(x) = \exp\left(-\frac{\ln R_r(x)(\lambda t)_a}{(\lambda t)_r}\right)$$

where x = value for subsystems A, B, or C

$(\lambda t)_a$ = no. permissible failures to be apportioned

= 0.105 (from Table I)

$(\lambda t)_r$ = no. estimated failures from RFM analysis reports

= 0.1397 (from Table II)

In this last table it is now easily seen that the difficulty in meeting the required reliability values set by the contract can be reduced and the goal for the individual designs readjusted to more easily attainable values.

"Subsystem A," who felt he had almost reached his goal by providing 0.963 to reach 0.9664, is now requested to improve his design to bring it to the level of 0.9720.

"Subsystem B," in seeing a goal of 0.9701 and is able to show only 0.931, might be inclined to become discouraged in this game and may contemplate defecting. The reapportionment, however, reassures him that with a more realistic goal of 0.9475 he might be able to improve the reliability of his design to that level.

"Subsystem C," who originally believed that he had exceeded his apportioned goal of 0.9605 by reporting 0.970, is surprised by being presented an extended reapportioned goal of 0.9774, which he must

Table III—Reapportionment (2nd Apportionment)

Equipment	$-\ln R_r(x)$	$\frac{\ln R_r(x) \cdot (\lambda t)_a}{(\lambda t)_r}$	2nd Apportioned Reliability
Subsystem A	0.0377	$\frac{0.0377 \times 0.1049}{0.1397} = 0.0284$	$R_{2a}(A) = 0.9720$
Subsystem B	0.0715	$\frac{0.0715 \times 0.1049}{0.1397} = 0.0539$	$R_{2a}(B) = 0.9475$
Subsystem C	0.0305	$\frac{0.0305 \times 0.1049}{0.1397} = 0.0229$	$R_{2a}(C) = 0.9774$
System	$(\lambda t)_r = 0.1397$	$(\lambda t)_{2a} = 0.1052(\lambda t)_a$	$R_{2a} = 0.9001$

now justify by improvement of his design. He understands that this is admissible on the fact that the original apportionment was only an estimate based on apparent complexity and not on actual complexity, which is later disclosed through RFM analysis.

Thus we find that "Subsystem A," "Subsystem B," and "Subsystem C" are all seriously engaged in design improvement for reliability toward goals which are realistic to each of them to be reflected in additional Reliability Figure of Merit Analyses and reapportionments until the over-all design reliability goal for the system is reached.

As we have shown, reliability is more than just numerics; during the design stage it is numerics with the dual purpose of defining the reliability goal and at the same time providing the tools and measures for its attainment. In addition, it provides a method whereby each reliability characteristic of the design can be evaluated on a comparative basis, spot-lighting problem areas and those aspects which will significantly influence the improvement of the system. The use of the reliability approach which we have discussed therefore enjoys the unique position of being both cause and effect; it not only tells us where we are going, but also tells us how to get there.

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Relationship BETWEEN PROCUREMENT AND QUALITY CONTROL

R. B. WALWORTH

Electronic Communications, Inc., St. Petersburg, Fla.

The relations between Procurement and Quality Control are vastly expanding and certainly require mutual understanding between the people in each function. The quality criteria necessary to meet an operational parameter must be practical. If they are not, manufacturing costs will be increased without merit.

Quality control, even at weapon systems concept, must be cognizant of the validity of quality *vs.* cost. It is in this area that a great deal of misunderstanding develops between quality control and procurement. Actually, many errors of conception occur at the design stage. The designer will select a tolerance of a higher safety factor than necessary with a tongue-in-cheek attitude that, if the manufacturer achieves only 80 percent of the requirement, an item will still perform satisfactorily. Here procurement is faced with buying a product of more precision than is actually required.

Mutual Contribution to Product Improvement

On the other hand, we frequently find a quality control and inspection attitude that is based solely on adherence to the blueprint and throws practicality to the wind. I personally quarrel with any attitude that is not progressive. I think internal correction is equally as important as the corrective actions necessary from the supplier's side to meet requirements.

I believe that purchasing and quality control can contribute greatly to the validity of design and the correction of over-emphasis, just as they are charged with the responsibility to exceed minimum demands. The purchasing manager must strive to perpetuate an attitude of economy with regard to procurement practices and obtain the greatest value for the least cost. When the quality emphasis becomes too demanding, the buyer might naturally feel that price is of minor importance. This opens a door to practices that can be harmful, since some suppliers will take advantage of these demands and build up their product to the point where its cost is far in excess of the actual requirement. It also should be kept in mind that the cost burden of defense equipment is borne by the American taxpayer, and therefore, it would seem that all of us have a common cause for examining carefully those specifications and requirements that are conceived in modern weapon systems.

The preceding remarks are not meant to convey the impression that whatever quarrel there is lies solely with quality control and engineering.

Purchasing's Attitude Toward Quality Control

There are also some faults on the purchasing side of the coin of which we are aware and which we must continue to improve. A strong quality function enables procurement to achieve better results because of its constant surveillance and its dissemination of objective quality information for which procurement is immensely grateful.

In our company we do a considerable amount of business with small suppliers. We find in many instances that they do not have adequate quality control procedures. The producers are frequently the same persons who do the inspection and there is always the perfectly human attitude of overlooking or rationalizing errors in the mistaken belief that the shipping schedule is of more importance than the product quality. ASQC can help to eliminate this practice.

Field Quality Surveillance Organization Assists Procurement

Within our company we have a Field Quality Surveillance group, reporting to the Purchasing Department, whose task it is to survey vendors and, when warranted, assist them in establishing better procedures and techniques. I believe that the integrity of suppliers is an equal factor both in small and large enterprises and that, for the most part, the supplier intends to deliver satisfactory material. Short lead time and pressure for adherence to delivery schedules are responsible for a certain amount of error.

I do not believe that we, in this type of industry, can ever expect to have the lead time necessary to overcome all possibility of error since the missile and weapon system business is such that the end product could very well become obsolete if an undue length

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of time is expended in development work. It is frequently necessary for missile and weapon systems to be conceived within a time period that was heretofore believed impossible. However, with national defense as its primary objective, it is necessary that we develop capabilities and speed to cope with this problem since there is every evidence that our enemies are working just as hard and—in some cases—with better success. Therefore we, dedicated to the American way of life, have no other choice than to adapt ourselves to overcoming the many complications and herculean efforts that continue to be demanded.

Within our company we warn the buyers to be continually on guard against associating themselves with any source of invalid product. It is recognized that it is quite human for a buyer to take up the cudgels in defense of a producer when the original selection of the source was his prime responsibility. However, to support such a selection is not only detrimental to the national effort but also will certainly reflect against the company's reputation.

QC Analysis Improves Sources

We believe that the greatest error in the selection of sources occurs at the inception of the bid and, therefore, that the buyer should be absolutely certain that these bids are solicited only from sources thoroughly capable of satisfactory performance.

Quality control analysis and evaluation contributes greatly to the recognition of good sources, provided, again, that the evaluation is on a sound practical base. We are dealing currently with a concept in which reliability has become a prime factor in the selection of components for modern weapons and control systems. The determination and achievement of this reliability is done at considerable expense and always takes a generous amount of time.

Qualified Products List Aids Reliability

The Qualified Products List is maintained by the government and is a valuable aid in the selection of components. However, one must be aware of the fact that, in order to appear on the Qualified Products List, there must be at least two sources of a component. All that the government certifies is that both vendors meet the required specification.

Even so, the selection of one of the two sources requires skill and judgment on the part of the buyer. In some cases, he must have advice from his quality organization as to which of these component sources is preferable since one of them can prove to be superior to the other in the machining and finishing operations in the buyer's shop. This can contribute to considerable price variation between identical components of one manufacturer as opposed to the other. It is generally assumed that this price variation is due to a higher quality which, if true, thoroughly warrants the expenditure of more money for the component that yields better assembly and less rework.

Check Lists for Emphasizing Critical Dimensions

We, on the procurement side, are thoroughly aware of the increasing necessity for technical review and new techniques to be established for proper quality evaluation. Great emphasis has been placed on statistics because many of the new techniques are based on statistical theory. There are times, however, when I disagree with an unbending adherence to these results, for example, when soft tooling is being used which does not lend itself to constant repeatability. In cases like this, we must adhere to the practical use of form, fit and function.

We believe that the use of check lists, which pick from the drawing the important factors with regard to form, fit, and function, is of great assistance in the acceptance of material and contribute to the general economy of procurement. If we were to treat the product with 100 percent inspection of all characteristics on the drawing, inconsequential deviations would be revealed, causing unnecessary rejection. I am fully aware that, on this topic, we may be entering into a realm of considerable disagreement; however, I understand that the true quality control concept agrees with this thinking.

It is difficult to present these thoughts without running the risk of implying that the procurement people are in favor of borderline quality. We are all too aware of the work load caused by rejection, the costs and time consumed in returns and replacement, the consequences of product failure, to want nothing but top quality from our vendors. Here we find the essence of good mutual understanding. I believe, that we purchasers must gain the complete confidence of the quality control group and we intend to continue to make sincere and determined efforts to establish that position. Furthermore, we are well aware that such a position once attained cannot endure unless we continue to work together in an atmosphere of mutual respect and understanding toward the common quality goal.

Quality Control Obligation for Good Interdepartmental Public Relations

The quality control organization also has its obligations and its share of public relations—if you will—in the direction of procurement. Many procurement people feel that inspectors are dedicated to reject and will pass a product only if there is no possible excuse to reject. This type of thinking, in my opinion, is fallacious because it is not in the best interests of our profession and our company. Obviously such an attitude on the part of inspection would be just as detrimental to the successful manufacture and assembly of a quality product as would be that of procurement maintaining a practice of buying borderline quality components. There must be an air of honest accord between the two functions. I feel that procurement must align itself completely with quality control in its approach to the vendor.

The Quality Control function can be of great assistance to procurement when a drawing error underspecifies or omits a dimension, for example, that creates a situation that clashes with the original design concept. In mechanical design, such a condition can develop by an accumulation of tolerances that leaves the supplier somewhat confused as to the importance of the various dimensions. Corrective action initiated by either Purchasing or Quality Control can eliminate this problem. There was a time when a strong argument could be offered against this kind of action because of the lack of technical skills in the inspection function. However, with the new techniques and talents present today in the quality control function, these problems can be approached from a sound basis by both organizations with the ultimate result of more practical design and an increase in product quality. I firmly believe

that close cooperation will lead to better performance of our common work. I am greatly in favor of members of our profession attending ASQC meetings and, conversely, that quality control people become interested in the functions of the Purchasing Agents Association.

National Association of Purchasing Agents

The National Association of Purchasing Agents is about 45 years old and, when one considers the humble origin of the Purchasing Agent, the evolution that has taken place in that time is certainly astonishing.

Some 45 years ago the Purchasing Agent was a clerk or foreman's assistant whose job it was to run to the store and pick up hardware and materials for use in manufacture. Later on, he was given an office under a stairway and very little—if any—clerical help.

Through the years the development of the Purchasing Agent continued to improve. Now there are many Universities today that give degrees to students majoring in Purchasing. Purchasing, like Quality Control, literally fought its way to a place at Management's table. Unfortunately the Purchasing profession has at times been plagued by certain elements of corruption which, I am happy to say, is constantly diminishing. However, those who fell by the wayside caused a serious amount of suspicion and lack of appreciation for the true concept of Procurement. I believe that these unpleasant attitudes are today largely a thing of the past.

Procurement's Constant Demand for Consideration of Cost

We are frequently criticized for constant preoccupation with cost. However, a Procurement organization cannot function successfully without due consideration for the amount of money it commits for its company. One of the principles that must be strictly adhered to is: "There is no price saving in buying a product of inferior quality for less money."

By the same token, the progressive Purchasing Agent today must keep his door wide open to possible cost reductions because American enterprise will continue to offer products of better quality at lower price structures. By being constantly alert the Buyer becomes aware of changes and is able to offer to his company new product developments that have profitable aspects.

We attempt to recruit the Buyers of the future from those who have majored in technical subjects and Business Administration, or who have obtained degrees in Purchasing, since the young man with this initial training can develop into a good buyer.

We do not assume that college training alone is sufficient to establish an individual as a good Buyer; but, we firmly believe that this background gives him the proper tools with which to develop by experience into a credit to himself and to his profession.

We feel that, in the very beginning, the expediting function is an excellent training ground since the Expediter becomes widely acquainted with certain aspects of Procurement which stands him in good stead when he becomes a Buyer and somewhat of a specialist in one field. I should like to emphasize that there is a great deal of discredit expressed in some quarters for the Expediter since he is often believed to be the lowest form of Procurement employee. However, the alert anticipation developed by good expediting can greatly strengthen the overall function of the Department and the company for which he works. In his phase of work he is just as interested in the prompt return of material for corrective action as he is in the anticipated receipt of that material. He, at this early stage, can develop a respect and desire for good quality practices and we look to the quality control group to help instill this respect in him.

After progressing through that phase of his training, he will start in the Junior Buyer capacity and continue to receive training for further progression.

Study Courses for Individual Improvement

In our company, we conduct a procurement course in which we deal with all the internal relationships of the Purchasing Department and conclude with actual procurement from external sources. At the conclusion of this course an aptitude test is given and the individual is rated with regard to how well he has absorbed the text. From a psychological standpoint, we make determinations as to his attitude, impression, and the curiosity factor. Just as in QC, it is extremely important to a Buyer to have a "large bump" of curiosity even though at times it may annoy the Sales profession to the point of frustration.

The curious will always find out more than those of us who are satisfied with things as they are.

Fortunately, from the outset of my career I have possessed a great deal of native curiosity which resulted in many questions that, by consultation with Quality Control, Production, Engineering and Technical Sales people, has greatly contributed to my general knowledge.

The greatest talents a Buyer can have are those of good judgment and common sense. In cases of particular stress, the panic button does us no good. On the other hand, if we seek the advice and combined knowledge of others, we will usually arrive at a solution to the problem.

Appreciation of the Military Quality Control Representatives

I should like to mention that in my opinion, the Government Quality Control representatives, both in this area and nationally, have certainly kept pace with the quality demands of industry and the Government. From the standpoint of adherence to specification and vigilance in seeing to it that subcontractors abide by Federal requirement, the Government Quality Control representatives have become more demanding, and properly so I might add, than was the case a few years ago. This is undoubtedly due to the increasing requirements for quality and reliability and we find, in most dealings with them, they are tough but fair.

Our organization, from the Procurement side, has been instructed to be most cooperative in their relationship with the military personnel with the knowledge that if we earn their respect, our work will go forward with superior quality and the minimum of delays.

I, therefore, wish to express my respect and admiration for the Government Quality Control representatives whom I feel receive too little attention of this kind.

BOOK REVIEWS

Charles R. Hicks, Editor
Purdue University, W. Lafayette, Indiana

PROGRESS IN NON-DESTRUCTIVE TESTING, Vol. I. Edited by E. G. Stanford and J. H. Fearon, The Macmillan Co., New York, N.Y. 1959 (copyright Heywood & Company Ltd. 1958), vii-267 pages, $12. Reviewed by J. W. Orner, chief, nondestructive testing, Watertown Arsenal, Watertown 72, Mass.

This book consists of a collection of eight separate technical papers by experts in their fields. It is the first of a series of books to be issued annually to "record progress in nondestructive testing by reporting, annually, scientific work which may lead to the development of new testing techniques or to the improvement of existing methods" as quoted from the Foreword. The broad scope of the book is indicated by the titles of the papers which cover various aspects of nondestructive testing.

The first paper, "Recent Developments in Industrial Radiography: Fluoroscopy and Screen-Intensification Processes," discusses experimental work on the sensitivity limits attainable in fluoroscopy and with one form of image intensifier. It considers the factors limiting attainable performance together with the likelihood of future progress in the field.

An experimental comparison of the limits of performance of two X-ray systems using tubes with widely differing focal-spot-sizes and three different types of fluoroscopic screens is adequately presented and illustrated with experimental data. A similar investigation on the performance of a Phillips Image-Intensifier Tube is described and other intensification systems are discussed. The paper ends with an interesting theoretical treatment of performance as limited by the effects of quantum fluctuations in the X-ray beam.

This paper gives a good review of the present state of fluoroscopy. The material presented is adequate. The conclusions are well supported by experimental data.

The second paper is entitled "Stress Wave Propagation as Applied to the Detection of Flaws by Ultrasonic Inspection." The first few sections consist of a brief study of the generation and behavior of ultrasonic energy transmitted through various media and across interfaces. The greater part of this paper deals with scattering phenomena, and the principles underlying reflection and refractions at boundaries. In conclusion, the author gives a brief but excellent discussion on the pressure amplitudes distribution in an incident ultrasonic beam.

The theoretical discussions set out in this paper are brief and rather incomplete as to application of these techniques to the detection of flaws. No mention is made of the stress wave propagation as applied to resonance techniques for thickness measurements, or to many of the conventional flaw detection methods.

The third paper, "Electromagnetic Methods of Testing Materials," includes testing of all types of metals by alternating magnetic fields. Concepts underlying recent developments are discussed. Emphasis has been placed on the more important concepts and techniques. The principle underlying effects due to eddy currents in conducting media, and domain phenomena in ferromagnetic metals are discussed and illustrated effectively. The section dealing with the significance of electromagnetic observations is well written and adequately covers the subject.

This paper offers an excellent review of electromagnetic testing and is one of the highlights of the book. The latter part of this paper is extremely valuable due to the discussions on applicable instrumentation circuitry and specific applications to typical problems. The author has succeeded in covering the concepts involved and gives some practical applications. The list of references is incomplete considering the abundance of literature available in this field.

The fourth paper, "Neutron Radiography," covers the potential value and limitations of this technique. Various types of neutron sources are discussed and the physical principles underlying their behavior are compared with the more conventional X — or gamma rays. Practical methods for detection and application of slow neutrons are covered. The paper includes examples of neutron radiographs.

The fifth paper, "Medical Aspects of Non-Destructive Testing," deals with the detection, measurement, and application of elect potentials generated in the human body. It is of no particular interest to a non-destructive testing engineer or technician. A discussion of the origin and characteristics of the electrical potentials produced is followed by a section covering instrumentation requirements. The title of this paper mentions nondestructive testing. However, the emphasis is placed on observed phenomena and its detection and display rather than on any abnormalities or disease.

The sixth paper, "The Applications of Damping Capacity for Investigating the Structure of Solids," is well written. It deals with the theoretical and practical aspects of damping capacity (or internal friction) of various types of materials. No at-

Quality and Reliability Technical Report

A new technical report in the quality control and reliability series has been published by the Office of the Assistant Secretary of Defense (Installations and Logistics).

This technical report, entitled "Tests for the Validity of the Assumption that the Underlying Distribution of Life is Exponential," may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (price 35 cents).

The content of this technical report was prepared by Dr. Benjamin Epstein and was published originally in the February and May 1960 issues of *Technometrics*. Dr. Epstein's paper is reprinted as a DoD Technical Report in order to make it more readily available to personnel in the DoD and in industry engaged in life and reliability testing. It serves as a companion document to DoD Handbook H108, "Sampling Procedures and Tables for Life and Reliability Testing (Based on Exponential)."

tempt is made to give details of experimental procedures, since these are covered in the literature, however, a few points of interest are mentioned. Definitions of damping capacity are given and are related to the concept of anelasticity. The author gives a brief account of some causes of damping in a discussion of thermoelastic effects and losses and dislocation phenomena as related to various kinds of materials. Material characteristics such as effects or conditions due to cold working, plasticity, phase transformations and fatigue are discussed.

The subject material is well illustrated with experimental data and information. In addition, some interesting correlations are mentioned, and the foundation is laid for the development of experimental techniques not usually associated with conventional techniques.

In the seventh paper, "Thermal Conductivity as a Non-Destructive Testing Technique," the author deplores the lack of recognition of thermal conductivity as a property useful for nondestructive testing. The paper begins with a brief, but interesting survey of some of the earlier techniques used for the measurement of rates of heat flow. Details are given of instruments of the thermal comparator type by which temperature differences are determined. The use of such comparators is discussed with reference to practical applications such as thickness determinations of nickel and copper deposits on steel. The paper concludes with a brief discussion on the subject of thermal conductivity and its relation to other physical properties.

It is hoped this paper will serve to stimulate interest in utilizing this property as a nondestructive testing technique. It has been somewhat neglected for application to practical testing problems until relatively recent years due, possibly, to the lack of suitable temperature measuring devices of the required sensitivity.

The eighth paper, "Nuclear Magnetic Resonance and its Application to the Testing of Materials," deals with part of a relatively new field of physical science which has been developed by the extension of spectroscopy into the radio frequency region of the electromagnetic spectrum. The underlying principles of nuclear magnetic resonance are explained from both the point of view of simple quantum mechanics and classical theory. Experimental methods of resonance excitation and detection and their application to the examination of the structure of matter are described.

The greater part of this paper is given to a theoretical study of the effects of (a) the physical properties of atomic nuclei, and (b) the structure of matter on nuclear magnetic resonance. Practical applications which are mentioned briefly in passing include the measurement of magnetic fields, detection and unambiguous identification of isotopes, and the analysis of mixtures.

This paper deals with a subject more properly related to a treatise on molecular physics. It describes a tool which, while not unrelated to non-destructive testing, would be of more interest to a research physicist.

This volume, since it is the first of a projected series, does not attempt to cover all aspects of nondestructive testing. Instead, the several excellent papers present the current status of only certain aspects of the general field. Future volumes, it is assumed, will broaden the coverage. The subjects of the individual papers dictated the academic level of presentation. Consequently, some areas of the book may not be of particular interest to the technician. Also, a more comprehensive subject index would enhance the usefulness of the book.

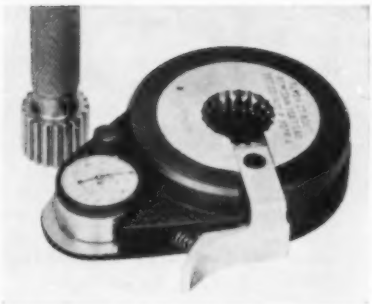
This volume should provide a valuable reference for those engaged in the general field of nondestructive testing. It is hoped that future volumes in this series will maintain the same general high level of quality.

Short Courses in Quality Control

Usual Time Course is Held	*Type of Course*	*Where Held*	*Course Director*
February	Basic	University of Illinois, Urbana, Ill.	John A. Henry
April	Advanced	University of Connecticut, Storrs, Conn.	Richard M. Story, Jr.
May	Basic (Textile Ind)	North Carolina State College, Raleigh, N.C.	David B. Stansel
June	Basic (Graphic Arts)	Rochester Institute of Technology, Rochester, N.Y.	Harold Kentner
June	Design of Experiments	Purdue University, Lafayette, Ind.	Charles R. Hicks
June	Reliability Institute	University of Connecticut, Storrs, Conn.	Richard M. Story, Jr.
June	Basic (Chem. Ind)	Rochester Institute of Technology, Rochester, N.Y.	Harold Kentner
June	Basic	TAPPI Statistics Course, Queens University, Kingston, Ontario, Canada	.....
June	Advanced	TAPPI Statistics Course, Queens University, Kingston, Ontario, Canada	.....
June	Advanced (Chem. Ind.)	Rochester Institute of Technology, Rochester, N.Y.	Harold Kentner
July 31-Aug. 11	Statistical Methods In Industry	UCLA, Los Angeles, Calif.	Edward P. Coleman
August 21-31	Basic	University of Michigan, Ann Arbor, Mich.	C. C. Craig
September 5-15	Advanced	Purdue University, Lafayette, Ind.	Irving W. Burr
September 10-22	Basic	University of Connecticut, Storrs, Conn.	Richard M. Story, Jr.

What's New?

ROY A. WYLIE, *Editor*



701—The new Vinco Splinedicator provides a fast, accurate measurement of effective tooth thickness or space width of involute splines. A Splinedicator may take the place of up to ten spline gages and absorbs no portion of the part tolerance. "Go" and "No Go" checks of the production part are obtained in one operation. Both ring and plug type Splinedicators are available in portable and bench models and can be made to check any type of spline in sizes from 0.18 inch P.D. and up.

* * *

702—Instrument Development Laboratories, Inc., has introduced the PYRO-650, an optical brightness pyrometer, that makes possible continuous recording and controlling of high temperatures in the range from 1200° to over 7000° F. The instrument is especially useful for precise temperature measurement of exotic metals and for temperature measurements in physical property studies relating to rocket and rocket engine performance. Additional uses are found in such industries as metals, cement, ceramics, glass, refractory materials, etc., where operations are carried out at high temperatures and where thermocouples or total radiation pyrometers cannot be used. The PYRO-650 eliminates the need for manual operation, which is common to most optical brightness pyrometers and thereby provides more effective process control and greater repeatability.

* * *

703—Trans Electronics Inc., has introduced an advanced model of its highly sensitive diode tester, with expanded capabilities in the semiconductor low current and high voltage ranges. The DT 924 is a back-current and saturation voltage tester with meter ranges of 0 to 3000 volts, 0 to 3000 microamps, and 0 to 3000 milli-microamps. Preset voltage ranges of 0-100-300-1000-3000 are provided and current ranges of 0-30-100-300-1000 are selected by keyboard switching. A three-position rotary switch selects the proper multiplier. The unit provides regulation of better than 0.1 percent; ripple and noise, 0.05 percent; output current is 0-1 ma; output voltage, 0-3000 volts. The diode tester is designed to serve equally well for laboratory analysis by skilled technicians or for quantity testing by less-skilled production line operators.

* * *

704—RCA has announced their entry into the nuclear gaging field with a complete line of gamma ray gaging systems for industrial applications. This is an extension of RCA's current product line of electronic inspection and control devices for industry. Gamma rays from a radioisotope source are passed through the material and received by a detector. The resulting strength of the beam as it strikes the detector is interpreted on an electronic display panel in terms of the material's thickness and density. Typical uses of gamma ray gaging are measuring precisely the thickness and density of such materials as pipes, steel plates, laminations of steel, nickel or other metals. The device may also be used for such automatic applications as the inspection and quality control of thickness and density in production operations, for the detection and control of voids and seams and for liquid level control of fermentation tanks, metal smelting furnaces and oil storage tanks. Since gamma gaging equipment avoids contact with the material under control, it is especially useful where adverse temperature, pressure, humidity and corrosive conditions, or remote locations make impractical other means of control.

* * *

706—The new Kin Tel 501B DC Digital Voltmeter measures positive or negative unknowns between 100 microvolts and 1000 volts. A model 456B digital voltmeter control unit contains the metering circuits while the measured values are displayed on a 473A digital readout, which presents four complete digits plus an over-ranging digit (0 to 1). This fifth digit gives ten times more resolution at the decade points — 1, 10, 100 — than four-digit machines that lose a digit changing from 0.9999 to 1.000. The 501B thus provides the useful accuracy of a five-digit voltmeter while retaining the stability, reliability and price advantages of four-digit instrumentation. Measurements are made in four automatic ranges selected by internal circuits. The solid-state metering circuit may be set to any of three sensitivities, can operate at gain −10 when unknown input is unstable. An input filter provides 60 db attenuation at 60 cps, more at 400 cps. The input impedance is 10 megohms at null. Special features include 100 percent over-ranging above standard four-digit instruments; single-plane wide-angle readout; ±0.0001 to ±1000.0 volts in four automatic ranges; accuracy of 0.01 percent ± 1 digit; input Z of 10 megohms; and constant calibration against internal standard cell.

ASQC Personnel Listing Service

A personnel listing service exists for the use of ASQC members only. Any member desiring to be listed as available for new employment opportunities should send a brief resume (on 3 × 5 file card, or cards) to ASQC Personnel Listing Service, Room 6185 Plankinton Building, 161 West Wisconsin Avenue, Milwaukee 3, Wisconsin.

All information will be kept confidential and those listed will be sent descriptions of all suitable opportunities for 60 days following receipt of this initial listing. If it is your desire to remain on the list after this period, you can do so by writing in to the same address and requesting an additional 60 day period. If you do *not* request an extension, your resume will be removed from the file on the assumption that you have made a successful connection.

Companies wishing to post positions available in the ASQC Personnel Listing Service should address all correspondence to the same address as above giving the educational and experience requirements, age and salary limits on each position. The position description should be limited to 100 words plus the complete name and address of the individual to whom resumes should be sent.

705—A new, comparatively low-priced electronic comparator that checks master rings and discs to an accuracy within two millionths has been announced by Federal Products Corp. This comparator can measure inside diameters from 0.040 inch to 4.760 inch, and outside diameters from 0 inch to 3.5 inch. These measurements are made with a constant gaging pressure since the contacts are mounted on a free-floating unit which eliminates friction. Two scales are immediately available by switching: 11,000 × magnification (0.000010 inch graduations) and 2200 × magnification (0.000050 inch graduations). The amplifier is transistorized and battery-powered for greater reliability and instant operation with no source voltage fluctuation. The mercury cell battery pack provides 1200-1300 hours of service. When not required full time for checking masters in the gage laboratory, the completely portable amplifier can be used with an electronic gage head for other measuring applications.

* * *

707—A new textile counting plate is available for the Flash-O-Lens illuminated magnifier for inspection work. The textile counting plate fits into the bottom housing on 5 × and 7 × Flash-O-Lens models, and is used for accurate pick counting, permitting quick measurements of ⅛ inch, ¼ inch, ½ inch and one inch. Flash-O-Lens illuminated magnifiers are available in both battery operated models, which are completely portable, or electric models for continuous use, which operate from any ac or dc outlet.

* * *

709—A new automatic color sorting machine custom-designed especially for tomatoes has been announced by Electric Sorting Machine Co. Tomatoes are conveyed to the sorter by a "Walking Board," which aligns them into seven rows that feed into bucket conveyors. From the bucket conveyor, each tomato is passed through a photoelectric color sensing device. Heart of this process is two photoelectric cells that receive light reflected from the tomatoes while they pass through a hexagonal viewing chamber. An optical system scans the tomatoes and passes reflected light over a striped mirror that divides it between the two photo tubes — one for red, one for green. The proportion of red to green determines the color category of the tomato. Tomatoes are sorted into red, green, dark green and pink. A fifth shade is also possible. Delivery chutes for each of the color categories convey the tomatoes to packing stations. One ESM Model G will release four to eight hand packers for other duties, as it will sort 450 tomatoes per minute with greater accuracy than hand sorting. Of major importance to repackers, the ESM Tomato Sorter grades and packs according to ripeness, thus determining the shipping dates for each group. The ESM Model G Photoelectric Tomato Sorter is available for purchase or for rent. Cost of the machine depends upon the size and the extent of the processing operation.

* * *

710—Michigan Tool Company has developed a simple tooth-space checking system that also graphically helps identify causes of tooth-spacing errors in straight or helical gears and splines. This system provides a simple means of measuring pitch-line run-out and eliminates its effects on an index check. The inspection can be accomplished without the necessity for analysis by a highly trained man. The new system is comprised of a checker, translucent charts and a light table. Used with this system is the Model 1132 tooth-spacing and concentricity checker, which consists of a bed with ways, an adjustable pointer carriage and slide, two dial indicators and a pair of centers. The standard unit will accept shafts up to 36 inches long and five inches OD having a wide range of pitches. The workpiece is positively indexed through use of an index plate. A rack-type pointer tip pivots so it contacts both flanks of a tooth near the pitch line at the time measurements are taken. The pointer unit can be swiveled so the tip matches the helix angle of the workpiece. Pointer tips can be quickly interchanged.

* * *

711—Model H5 Wallace Dead Load Micro-Hardness Tester for rubber, rubber-like materials and plastics eliminates the need to mould standard size test specimens and permits the hardness of small parts sheets and irregular shapes to be measured directly. The depth of indentation is measured electronically. The basic machine consists of an indentor and a means of applying a minor and then a major load. For 'O' rings, small pieces or seals, and irregularly shaped parts, it provides a test not obtainable by other methods. It will give accurate readings on specimens less than ½ mm (0.01969 inches) thick. This feature is vital where only a very thin layer may be available, such as an oil seal. The unit can measure the hardness or softness of insulating material on electric wire without stripping the wire or moulding a specimen. By taking a series of readings at convenient time intervals, it is possible to plot a graph relating indentation and recovery to time. Model H6 is for rigid plastics and for measuring the state of cure of synthetic resins and fiber reinforced materials. Model H7 is available for Micro-Hardness measurement of extremely thin surface coatings. It will measure differences of indentation on films as thin as 0.0005 inches and show variations in hardness occurring over the surface of a single specimen.

* * *

712—A new industrial x-ray unit costing under $1000., which will produce both fluoroscopic images and radiographs of internal structures such as switches, transistors, condensers and relays, is being manufactured by Universal X-Ray Products, Inc. It will inspect a variety of materials including wood, paper, leather, rubber, plastic, aluminum, copper, etc. The "Thru-Vu" consists of a self-contained, compact x-ray generator, stand and specimen case for viewing and taking films. The unit weighs about 80 pounds, plugs into any 115 volt outlet and dimensions are 12 x 14 x 26 inches. It is approved by Underwriter Laboratories.

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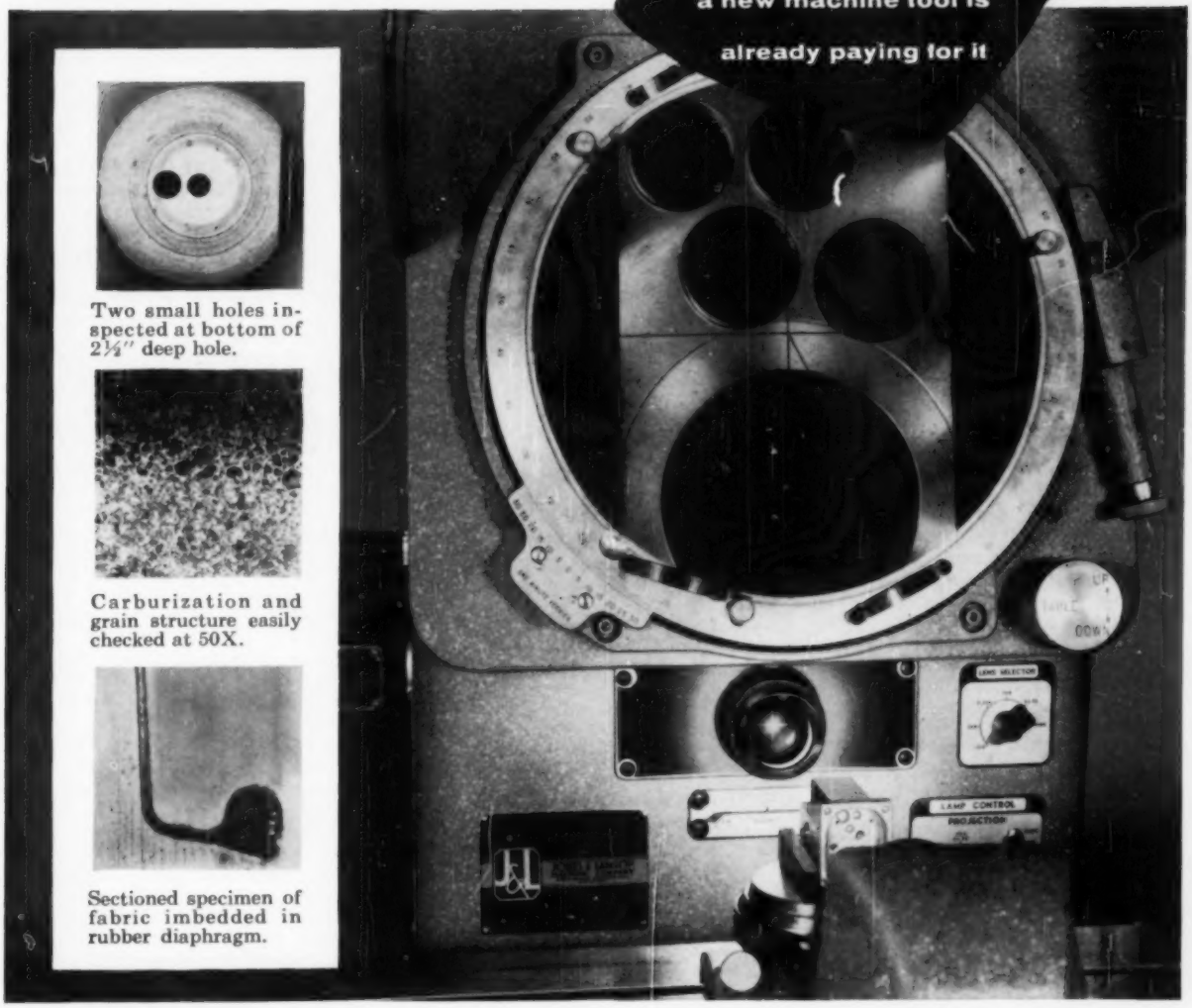

New reflection unit makes "tough" inspections easy

Now, users of J & L FC-14 and TC-14 Optical Comparators can easily and accurately inspect cast materials, deep holes, and penetration of heat treat, and can make their over-all inspection operations more efficient than ever before.

J & L's new Normal Reflection Unit, shown here, is designed to produce the maximum amount of reflectivity, *regardless of the surface finish of the part being inspected.* This new unit gives brighter-than-lifelike images, with clean, razor-sharp definitions, without heat and without distortion.

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Turret Lathes • Automatic Lathes • Tape Controlled Machines • Thread & Form Grinders • Optical Comparators • Thread Tools

708—The Van Keuren Model LWM-60 light wave micrometer is a recent addition to the Van Keuren line of measuring instruments. It reads directly on the handwheel to 0.00010 inches and on the vernier to 0.00001 inch. It has a capacity of zero to two inches. It is a compact complete unit and requires no gage blocks. Designed as an inspection standard, it measures directly plug gages, measuring wires, setting blocks, cylindrical shapes and pitch diameter of threads and gears.

* * *

713—An improved portable thermistor psychrometer, which quickly gives precise wet bulb or dry bulb readings for determining relative humidity, absolute humidity, dew point, or enthalpy in air and other gases, is one of a range of temperature and humidity instruments offered by Atkins Technical, Inc. The instrument, the A+ Hygrophil, uses tiny thermistor beads as resistance thermometer elements. Response time is unusually rapid because of the small mass of the temperature sensing thermistor beads and because of the instrument's controlled air system. Since both wet and dry readings are usually obtained within ten seconds, readings can be taken in confined spaces with limited air available for measurement. Air speed is controlled by a built-in fan system. Air is drawn over the two sensing thermistors, one dry and one kept wet with a built-in wick and water system. Temperature is indicated directly on the three overlapping scales of the meter in increments of ½°F or 0.2°C. Accuracy of indication of Relative Humidity is thus better than 0.5 percent over most of the scale. The entire system is powered by standard mercury batteries. The A+ Hygrophil can be used for readings in bases between 10° and 176° or the equivalent −10° to 80°C. This very wide span can be monitored accurately for all normal humidities; the 10 percent to 90 percent range being suitable for calibration quality measurements. Major applications are in testing and development work, storage of foods and other moisture sensitive materials, meteorology, air conditioning and other environmental control fields. The A+ Hygrophil is supplied in a lined wooden or plastic case complete with barrel extension piece, distilled water container, extra wicks, operating instructions and a booklet of dew point and relative humidity tables. For explosive atmospheres an A+ Hygrophil with a spring-wound fan motor can be supplied.

New Literature

730—Literature describing the new Green-Bartlett technique of high-speed fully-automatic color measurement is now available from Allied Research Associates, Inc. Designed to provide precise color signatures at rates as high as 30 samples per second, the described equipment is well suited for feedback process control, continuous color inspection, and high-speed color sorting and grading. Information on this equipment, which has already been applied for industrial production color sorting, is provided in two four-page brochures, one on general product sorting capabilities and the other describing technical details and applications of the colorimeter.

* * *

731—A new, 12 page catalog complete with prices and descriptive specifications on over 400 different types and sizes of Precision Surface Equipment has been announced by the Challenge Machinery Co. This new catalog includes greatly expanded information on granite surface plate equipment and information for tool designers on semi-steel angle plates.

* * *

732 — Measuring and recording roundness flatness, roughness, waviness, scratches, flaws and total surface profiles are described in detail in the new eight-page, four color brochure on the Proficorder. Included in the brochure are many typical profile records reproduced in full color, showing a wide variety of surfaces. Used in both the laboratory and shop, the Proficorder provides profile records of practically any types of surface that can be produced by normal production methods including metals, plastics and glass.

* * *

733—Standard Gage Company has announced the release of their new Air Gage Engineering and Purchasing Guide. This 32 page illustrated catalog of Standard Air Gages is designed as a tool to help in proper gage selection. It is also a source of basic design data for the gage engineer and complete ordering information for purchasing personnel.

* * *

734—Chemical Service Laboratories announces the introduction of their Standardettes — chemical standards which permit laboratory technicians to accurately standardize titrating solutions to four-figure accuracy in a matter of minutes. A six page illustrated folder has just been released, giving detailed descriptions, prices, packaging and applications of Standardettes in graduate research, water analysis, sewage treatment, electroplating control, and in the chemical and food processing industries.

* * *

735—The Exact Weight Scale Company has published an eight page two-color illustrated catalog on Shadograph scales and weighing equipment for industrial, laboratory and commercial applications. In addition, they have made available a reference manual for the application of automatic weight sensing systems. The eight-page illustrated manual is designed as an idea stimulator to show how the principle of weight sensing or measurement of force can be utilized to perform a wide variety of production and quality control functions.

* * *

Inquiries for the following new literature may not be addressed to Product Education Service. Requests for literature and payments, when required, should be sent to the companies listed below.

* * *

The American Society for Testing Materials announces the availability of a 62-page list of publications. Published in April of this year, the list describes the Symposiums, Manuals, Special Publications, Indexes, Compilation of Standards, Charts, Reference Photographs and Reports published by the Society throughout the years. More than 300 items are fully described, 40 of which are new and not previously listed. The list may be obtained free for the asking from the American Society for Testing Materials, 1916 Race Street, Philadelphia 3, Pa.

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For complete information and demonstration contact nearest representative.
Anderson-Stone Engineering, Newton, Mass.
Brogan Associates, Mineola, Long Island; Syracuse, New York
J. E. Cuesta Company, Paoli, Pennsylvania
Datronics, Houston, Dallas, Fort Worth, Texas
Kittleson Company, Los Angeles, Palo Alto, California
S. S. Lee Associates, Washington, D.C.; Baltimore, Maryland; Winston-Salem, North Carolina; Orlando, Florida
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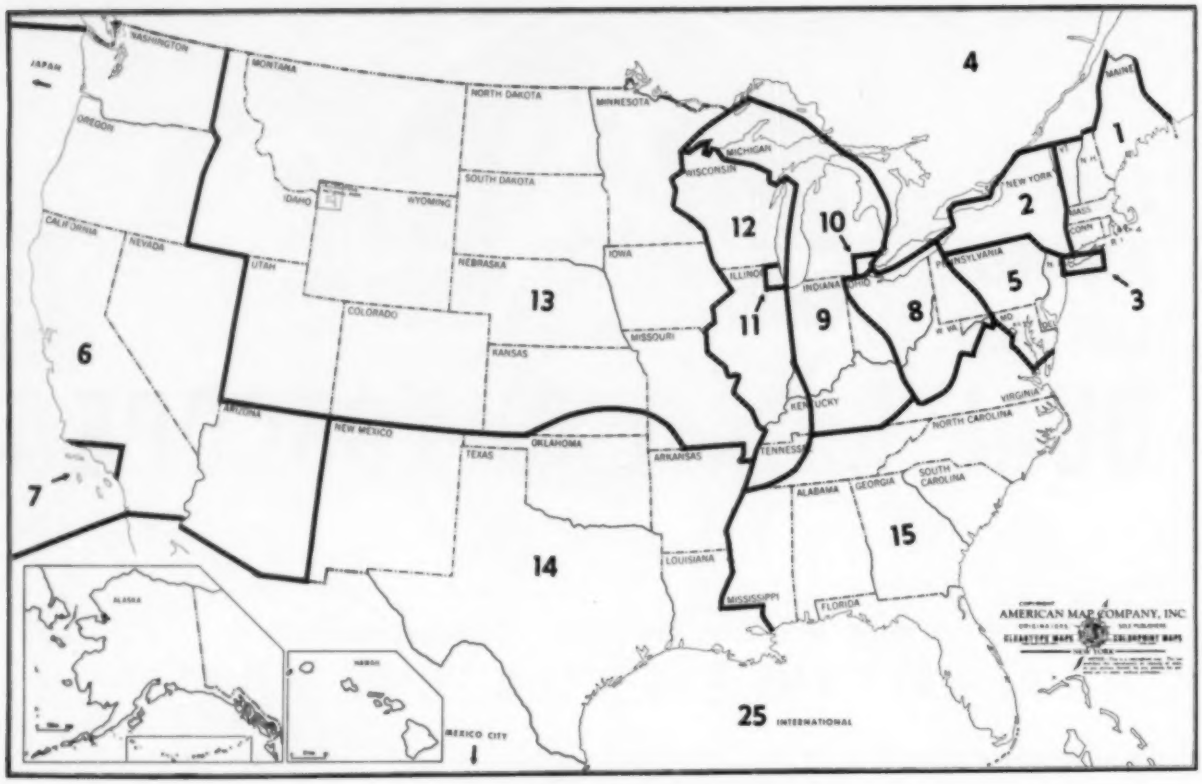
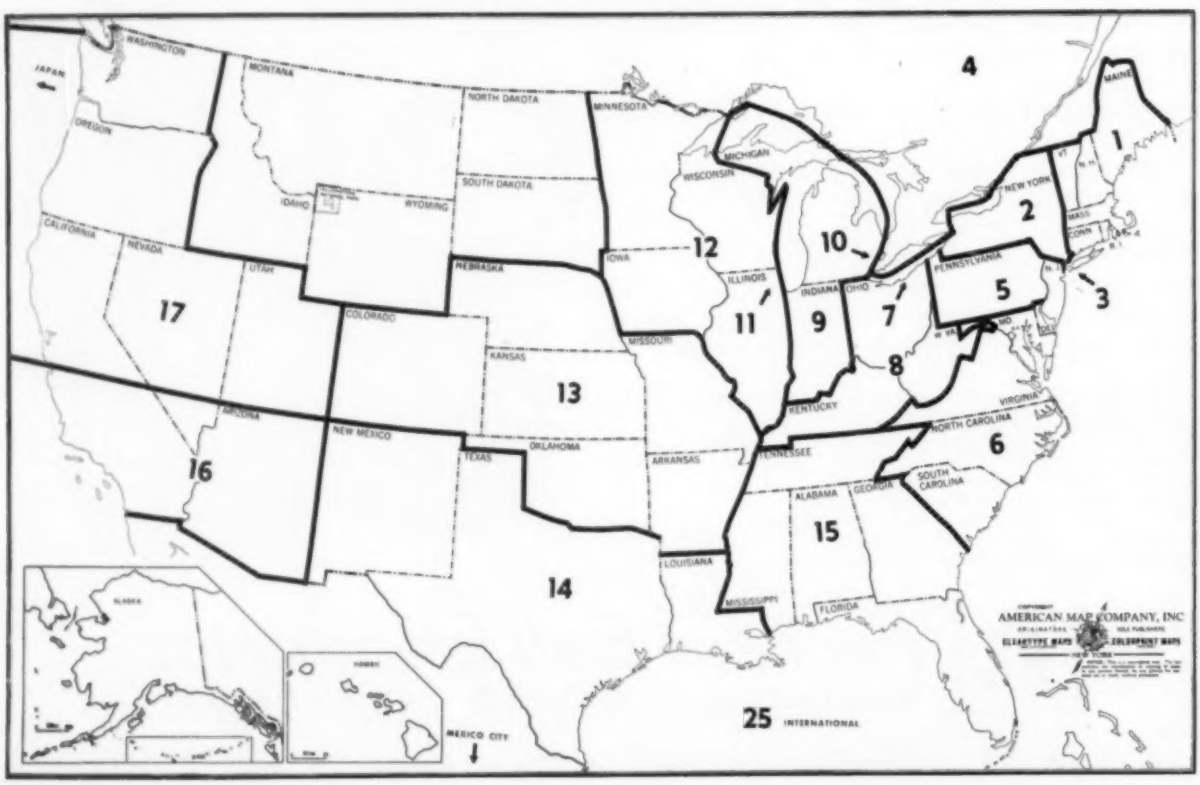


OLD DISTRICT STRUCTURE

Expires June 30, 1961



ASQC News

David S. Chambers, Executive Secretary

The New Governmental Structure Plan, which was approved in principle by the membership in the 1960 Annual Postal Ballot, and for which specific Amendments were presented and adopted in the 1961 Ballot, will produce a number of fundamental changes in Society organization. The changes cannot be made all at once, however, so the purpose of this discussion is to indicate the steps and timing of the reorganization.

Regional Delineation

The principal feature of the new Plan that controls the timing is the provision that the Board of Directors shall be composed of one Director elected from each of 15 Regions instead of "approximately 25" elected from the present 17 Districts.

Acting on the vote of intent of last year, a committee of the Board during the past year developed a new Regional Delineation. These new Regions were adopted by the Board at its February meeting to become effective on July 1, 1961. Attached are maps showing the new Regions in relation to the old District structure.

With the establishment of the new Regions on July 1, election of directors can be held during 1961-62 so that the new Plan will become fully operative with the 1962-63 year.

Election of Regional Directors

In the long-run, each director will serve a two-year term, but alternated so that only half the 15 directors will be elected each year. To begin the program, however, all 15 Regional Directors will be elected during 1961-62, with those from the odd-numbered Regions serving only a one-year term.

Beginning in 1961-62, the elections will be conducted by the Executive Secretary of the Society. These have been conducted by the District Representatives in the past, but the reorganization plan includes elimination of the District Representatives as well as the districts.

Lame-Duck Provision

Members of the present (1960-61) Board of Directors will be gradually phased out as the new plan goes into effect. Half the Board was elected last year and their terms expire on June 30, 1962, so with these directors there will be no problem since the expiration of their term coincides exactly with the installation of the new Board.

The terms of the other half — directors elected this year (1960-61) — will not reach expiration until June 30, 1963, one year after the new Board takes effect. These directors, therefore, will be given the option of (1) resigning or (2), having been duly elected for two years, of continuing to serve on the new Board for another year. In both cases, directors elected through the District delineation arrangement will be serving during the 1961-62 year without such delineation, since the Districts have been replaced by the new Regions.

Election of Officers and Directors at Large

During the year 1961-62, the usual slate of officers and, in addition, four Directors-at-Large, are to be elected by the membership at the time of the Annual Postal Ballot in the Spring to serve for the 1962-63 year.

The candidates for these elective positions will be nominated by the 1961-62 Nominating Committee, which will consist of six Directors and the Junior Past President.

In the long-run, the four Directors-at-Large will be elected on the same basis as the Regional Directors — two each year for two-year terms. To start the system, however, all four will be presented on the 1961-

Old and New Section Code Numbers by Region

On July 1, 1961, the Society is officially changing its structure from 17 Districts to 15 Regions. This change has necessitated changing some of the section code numbers used by the national office. Published below for your reference is the list of both old and new numbers. The new number is the one that appears on your new membership card.

OLD	NEW	NAME
	0100	Boston
	0101	Buzzards Bay
	0103	Hartford
	0104	New Hampshire
	0105	New Haven
	0106	Pittsfield
	0107	Rhode Island
	0108	Southern Connecticut
	0109	Western Massachusetts
	0110	Worcester
	0200	Albany
	0201	Buffalo
	0202	Corning-Elmira
	0203	Mid-Hudson
	0204	Rochester
	0205	Binghamton
	0206	Syracuse
	0207	Utica
	0300	Metropolitan
	0400	Hamilton
	0401	Montreal
	0402	Toronto
	0403	University of Western Ontario
	0404	Windsor
	0500	Allentown-Bethlehem
	0501	Danville-Sunbury
0600	0502	Baltimore
	0503	Harrisburg
	0504	Lansdale
	0505	Philadelphia
0602	0506	Delaware
	0507	Scranton-Wilkes Barre
	0508	Trenton
0604	0509	Washington
1603	0600	Orange Empire
1602	0601	Santa Maria-Vandenberg
1604	0602	San Bernardino
1605	0603	San Diego
1703	0604	San Francisco
1705	0605	Sacramento
1704	0606	Seattle
1701	0607	Portland
1609	0608	Phoenix
1608	0609	Tucson
1700	0610	Japan
1601	0700	Los Angeles
0700	0800	Cleveland
	0801	Columbus
0506	0802	Pittsburgh
	0803	Parkersburg
	0804	Toledo
	0805	Youngstown
	0806	Charleston
0605	0807	Cumberland
	0808	Lima
0502	0809	Erie
	0810	Akron-Canton
	0811	Mansfield
0800	0900	Cincinnati
	0901	Grand Rapids
	0902	Greater Muskegon
	0903	Indianapolis
	0904	Muncie
	0905	Northeastern Indiana
	0906	South Bend-Mishawaka
	0907	Richmond, Ind.
	0908	Battle Creek-Kalamazoo
0802	0909	Dayton
0807	0910	Hamilton-Middletown
0809	0911	Lexington
1504	0912	Louisville
	1000	Greater Detroit
	1100	Chicago
	1200	Central Illinois
0900	1201	Evansville-Owensboro
	1202	Milwaukee
1303	1203	St. Louis
	1204	Racine
	1205	Rockford
	1206	Winnebago
	1207	Kankakee-Joliet
	1208	St. Charles
	1209	Southern Illinois
1505	1210	Memphis
	1300	Denver
	1301	Kansas City
	1302	Omaha-Lincoln
1201	1303	State University of Iowa
1203	1304	Minnesota
1702	1305	Salt Lake City
	1400	Albuquerque
1306	1401	Joplin
	1402	Dallas-Ft. Worth
	1403	Mexico City
	1404	San Antonio
	1405	South Texas
	1406	Waco
	1407	Central Arkansas
1307	1408	Oklahoma City
1305	1409	Tulsa
1304	1410	Wichita
	1500	Birmingham
	1501	Chattanooga
	1502	Georgia
	1503	Huntsville
0601	1504	Piedmont
0603	1505	Richmond, Va.
	1506	Tennessee
	1507	Pensacola-Mobile
	1508	St. Petersburg-Tampa
	1509	Orlando-Cape Canaveral
	1510	Northeast Tennessee
0606	1511	Radford-Roanoke
	2500	Chapter #1

62 annual ballot. The two receiving the highest number of votes will serve two-year terms; the other two will serve one-year terms.

District Representatives

With the termination of District delineation, as of June 30, 1961, there will be no Constitutional provision for District Representatives. As noted above, one of the important functions of the District Representative — the election of Regional Directors — will thereafter be the responsibility of the Executive Secretary.

The other major function performed by the District Representative—that of assisting the sections to maintain a close association among themselves and liaison with national affairs—will be conducted by the Regional Director.

Complete Activation, July 1, 1962

With the transition steps discussed here completed during the coming year, the new Governmental Structure Plan will become fully effective on July 1, 1962. At that time the newly constituted Board of Directors, Executive Committee, Finance Committee, and Nominating Committee will become operational. The membership and duties of these governing groups are discussed in detail in the amendments in the Annual Meeting Notice recently sent to the members with the annual ballots.

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CRAFTSMANSHIP—A MEANS OF IMPLEMENTATION, R. D. Ginter
UP-TO-DATE QUALITY CONTROL IN A CHANGING AEROSPACE WORLD, Col. O. C. Griffith
QUALITY ACCEPTANCE MEASURES—ADL vs. AQL, G. V. Herrold
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ASQC Honors

Recent Elections to Fellow

T. R. BAINBRIDGE

Northeast Tennessee Section

Mr. Bainbridge is assistant superintendent, A. Y. Quality and Standards Department, Tennessee Eastman Co., Kingsport, Tenn. He has been a senior member since 1947.

He was a charter member of the Tennessee section and original Textile Technical Committee; later of the Northeastern Tennessee section and Textile Division.

He has held both section and division offices, written several papers, taught courses in statistics covering a variety of subjects, and has made a number of talks at various section meetings and regional or division conferences.

Mr. Bainbridge is a native of Savannah, Ga. and a graduate of Clemson College, Clemson, S.C.

ENRIQUE BLANCO

International Chapter

Madrid, Spain

Dr. Blanco is a founding member, ASQC, and an honorary member of the Iowa section, ASQC. He is a Fellow of the Royal Statistical Society, a Fellow of the American Statistical Association, a permanent member of the International Statistical Institute, and a member of the European Organization for Quality Control.

He attended courses at Columbia University in 1945, Stanford University in 1947, and the University of California, Berkeley, Calif., in 1950. He received his Sc.D. in 1945 and Doctor of Economics in 1950 from the University of Madrid.

In Spain, he is charged by the Ministry of Commerce — Department of Supply and Transport (C.A.T.) to develop and organize the Food Quality Control program for consumer protection as Head Director of the Food Technical Cabinet.

From 1944-52, he served as professor of statistical methods, Faculty of Economics, Madrid University, and from 1952-61 in the School of Statistics.

Since 1946, Mr. Blanco has worked to introduce statistical quality control into Spain, and is founder of TEASA management organization in 1950.

He organized the meeting on life testing and reliability for the 1961 Paris session of the International Statitical Institute. He has also prepared a paper for the 1961 Turin meeting of the European Organization for Quality Control.

HAROLD J. DAVIS

Boston Section

Mr. Davis received the degree SB in EE from the Massachusetts Institute of Technology.

After several years he became an inspection engineer with the Signal Corps. During World War II he served as an inspection officer with the Signal Corps.

Since 1948 he has been with Raytheon Company as a quality and reliability engineer.

He has been active for many years in the Boston section, ASQC, and has been a past chairman of that section.

Mr. Davis is currently a Lieutenant Colonel in an Army Reserve Research and Development Unit.

DAME S. HAMBY

Piedmont Section

Dr. Hamby is Burlington Industries Professor of Textiles, Department of Textile Technology, North Carolina State College, Raleigh, N.C. He received his bachelor of Textile Engineering from Auburn in January 1946.

From 1937 until he joined North Carolina State College in 1948, Dr. Hamby was with Goodyear Tire and Rubber Co., Atco, Ga., Celanese Corporation of America, Rome, Ga., and B. F. Goodrich, Akron, O.

He is a past chairman and a past treasurer, Textile Division, ASQC. In the Division he was also chairman of the long range planning committee and a member of the awards committee.

He has served on the following ASQC committees: executive committee, Carolinas section; awards committee; editorial board, and the committee for international relations.

Dr. Hamby served as technical director for the Textile Supplement to *Industrial Quality Control*, 1952, 96 pages, and as technical editor for Vols. I through VI of *Textile Quality Control Papers*, which total 921 pages.

He has also published several other books, articles and papers in the field of textiles. Among his more recent articles is "The Analysis of Variations for Certain Physical Properties of Combed Cotton Yarns," by Hamby, Stuckey, Gast & Hader, *Textile Research Journal*, 1960, Vol. 30, No. 6, pp. 435-443.

His affiliations include Sigma Xi; fellow, Textile Institute; American Association of Textile Technologists; American Society for Testing Materials, and Sigma Tau Sigma.

JOHN D. HROMI
Pittsburgh Section

Mr. Hromi is plant coordinator-operations analysis at the Gary Steel Works of the United States Steel Corp., Gary, Ind.

He received a BS in Mathematics from Carnegie Institute of Technology in 1948, a BS in Electrical Engineering from Clemson College in 1950 and an M Litt in Mathematics from the University of Pittsburgh in 1951.

He has taken advanced statistics courses at Virginia Polytechnic Institute, Oklahoma State University, and North Carolina State University.

Mr. Hromi is the author of a number of papers on experimental designs and has also presented talks to national and local gatherings of professional societies like the ASQC, the American Statistical Association, the National Association of Corrosion Engineers, and the American Foundrymen's Society.

Recently, Mr. Hromi and Cuthbert Daniel prepared a two-day course on "Fractional Factorial Experimentation" for the education program sponsored by the Chemical Division, ASQC.

Mr. Hromi is past chairman of the Pittsburgh section, ASQC, and a member of the Metals Technical Committee. Other memberships include American Statistical Association, The Institute of Mathematical Statistics, Operations Research Society of America, and The Institute of Management Science.

GEORGE C. LECKY
Pittsburgh Section

Mr. Lecky received the degree of BS in Chemical Engineering from Carnegie Institute of Technology in 1931.

He joined the F. J. Kress Box Company in 1934 as a quality control engineer and later became director of quality control. In 1959, the F. J. Kress Box Company became part of the St. Regis Paper Company and Mr. Lecky is now technical representative of the Corrugated Container Division, St. Regis Paper Co.

Mr. Lecky is past chairman of the Pittsburgh section, ASQC, and also a member of the Technical Association of the Pulp and Paper Industry.

He served in the Chemical Corps in World War II and recently retired as a lieutenant colonel in the U. S. Army Reserve.

ALLAN M. HULL
San Francisco Section

Mr. Hull received his BS degree with majors in mathematics, physical science, biology and education from Nebraska State Teachers College in 1938 and his BS degree in biology from University of Colorado in 1940.

He was an instructor in aircraft maintenance with the Air Force Technical Training Command for two years before joining the Engineering Department of United Air Lines in Chicago as Chief of Maintenance Records.

Later he was made supervisor of maintenance and reliability analysis, at which time he made the first known application of statistical quality control to airline maintenance and reliability analysis. Approximately three years ago, he was made engineering and maintenance administration coordinator of data processing.

He has been active in Boy Scouts, and in his church as Deacon and an Elder. He has served in various capacities in San Francisco section, ASQC, including that of chairman.

He was chairman of the 1957 Western Regional Quality Control Conference, and publicity chairman for the 1960 ASQC Convention in San Francisco, Calif. He was Society Treasurer for two years, 1958-60.

Mr. Hull has presented papers at local, regional, divisional and ASQC conventions.

PEDRO MENDIZÁBAL
International Chapter
Bilbao, Spain

Mr. Mendizábal graduated as Ingeniero Industrial at the Bilbao Engineering School and as Intendente Mercantil at the Bilbao School of Commerce.

Apart from having held positions in several firms, he has been lecturing at the Engineering School as professor of hydraulic engines general theory since 1926, and later on, as professor of mathematical and applied statistics.

He is the author of a book on quality control and of numerous papers dealing with statistical methods in industry. He has been devoted to the expansion of these methods through lectures, courses, etc. At present, he is head of the Applied Statistics Department at the "L. José de Torróntegui" Testing and Research Laboratories, Bilbao.

As Spanish representative, he is a member of the EOQC Sampling Committee.

A. L. RAICH
Denver Section

Mr. Raich was born in Pueblo, Colo., and attended the University of Denver from 1941-47, with a three and a half year break for U.S. Navy service as an electronics specialist.

After he received his BS in Chemistry from D. U., he took graduate work in Oceanographic Chemistry at the University of Washington, receiving an MS in 1949.

Statistical experience began with work at the Denver Research Institute in 1947, research on surface tension of milk with Dr. C. S. Whitnah, winner of the 1949 Borden Award for Dairy Research. Studied Interpretation of Experimental Data under Dr. Mario Iona of Climax Observatory. Graduate research on separation of strontium from calcium in seawater, now of great importance in radiation fallout studies.

Employed by CF&I as Metallurgical Statistician in 1949. Recalled 1950-52 for active U.S. Navy electronics work in Hawaii. In 1956-57, he served a one year assignment as Statistical Expert with United Nations technical assistant program in India; worked with Indian Statistical Institute and a great variety of large and small industrial establishments throughout India. Mr. Raich is now QC statistician at Colorado Fuel and Iron Corp., Pueblo, Colo.

Since he joined ASQC in 1949, Mr. Raich has served as a vice chairman, Denver section, of which he is a charter member; as a ASQC Annual Convention speaker and moderator; with the Education and Training Committee and Metals Technical Committee, and as a regional conference speaker.

He has also been active with the American Society for Metals, 1952 to date; American Chemical Society, 1948-1960, and Quality Control Association, India, 1957 to date.

JOHN H. REYNOLDS

Georgia Section

Mr. Reynolds studied chemical engineering at the Georgia Institute of Technology, Atlanta, Ga., and received the degrees of BS and MA in Mathematics from the University of the South, Sewanee, Tenn. He continued graduate study in mathematics at the University of Wisconsin, Madison, Wis.

In 1938 he became associated with Celanese Fibers Co., a Division of Celanese Corporation of America, and is currently senior quality control engineer.

Mr. Reynolds was chairman of the Atlanta Society for Quality Control when it became the Georgia section, ASQC. Subsequently, he served a second term as chairman and a term as vice chairman.

He was chairman of the steering committee for the formation of the Textile Division and served as chairman for one term, vice chairman for one term, and as secretary for two terms.

On the Society level, he has been a member of the Committee on Education and Training (two terms), the General Technical Council, and the Film Library Committee.

Technical papers include "Two Textile Applications of the Chi-Square Control Chart," which appeared in the *Textile Division Supplement to IQC* in August, 1952, and "Controlling the Control Laboratories," in *Industrial Quality Control*, July, 1954.

DR. HOWARD L. STIER

Washington, D.C. Section

Dr. Stier, director of the Division of Statistics, National Canners Association, received a BS degree and a special teacher's diploma from the University of Maryland in 1932.

After working for two years for the U.S. Department of Agriculture at the Beltsville Research Center, he returned to take graduate work in horticulture at the University of Maryland in 1935 where he received his MS degree in 1937 and PhD in 1939. During this period he served as a research assistant on the staff of the University of Maryland Agricultural Experiment Station, and subsequently held the rank of assistant professor of horticulture.

In 1941, he was ordered to active duty with the Army Quartermaster Corps with the rank of first lieutenant. He was discharged in 1946 with the rank of colonel, being awarded the Legion of Merit for his wartime service.

Dr. Stier's research has included work in horticulture (vegetables) and plant physiology. Throughout his research and education experience he maintained an active interest in statistics and the application of statistical techniques to the analysis of experimental data and the design of experiments.

Dr. Stier is the author of a number of articles in the field of horticulture, plant physiology, statistics and management control. He also has contributed a number of articles to trade journals and other periodicals.

Dr. Stier was chairman, Washington, D.C. section, ASQC, 1954-55, chairman, Food and Allied Industries Technical Committee, ASQC, 1956-60. He has been active in organizing food industry activities in ASQC since 1953. In 1955 he was chairman, Middle Atlantic Conference, ASQC. He has organized and chaired a number of sessions at Annual ASQC Conventions on applications in the food industries. He is the author of ten papers on statistical QC.

Since 1952, Dr. Stier has been active in organizing and conducting short courses in statistical QC for food processors. He participated in the first course of instruction in SQC offered by the Washington, D.C. section, ASQC.

MAE-GOODWIN TARVER

Chicago Section

Miss Tarver was graduated from the University of Alabama with degrees in Chemistry, Metallurgy, and Ceramics. Miss Tarver has also done postgraduate work in statistics, mathematics, and statistical quality control at the University of Chicago and Illinois Institute of Technology. She is a member of Sigma Xi and Chi Beta Phi.

In 1941, Miss Tarver was employed in the Research and Development Department (Metal Division) of Continental Can Co., Inc., as a research engineer. At the present time, she is the research statistician in that department.

Miss Tarver has been active in the Chicago section, ASQC, and since 1955 she has taught applied statistics and SQC in that area. She has published papers on the application of SQC and statistical methods in the food industry. She is currently secretary-treasurer of the Food and Allied Industries Division, ASQC.

SIGMUND P. ZOBEL

Buffalo Section

Mr. Zobel has BS and MBA degrees from the University of Buffalo. After teaching various statistics courses at the University of Buffalo for ten years, he left full-time teaching to enter industrial statistics, while continuing to teach statistical quality control and business statistics in the evening division.

From supervisor of statistical quality control at the Pratt and Letchworth Division, Dayton Malleable Iron Co., he went to the Carborundum Company in 1958, as a senior engineer in the Quality Control Branch of the Research and Development Division. In 1960, he became manager, quality control, in the Electro-Minerals Division.

He has held various offices in the Buffalo section, and in the Administration Applications Division, where he is the chairman elect for 1961-62.

Mr. Zobel has also been secretary of the ASQC Committee on Relations with other Professional Societies.

In addition to organizing three all-day quality control conferences for the University and the Buffalo section, he has given many papers at local sections, regional conferences, and annual conventions of ASQC. Several of these papers have been published in *Industrial Quality Control*, conference or convention transactions, and the *Journal of the American Statistical Association*.

ASQC Announces

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(as of April 30, 1961)

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BRUNE, FEDERICK G., Royal Oak, Mich.
CIAVOLA, PHILIP A., Clinton, Mass.
CLYMER, BENSON, Fayetteville, N.Y.
DE LONG, RUSSELL I., San Diego, Cal.
HAYTER, WALTER T., Beverly Shores, Ind.
HIGGINS, RICHARD G., Washington, Iowa
HUFF, GEORGE K., San Diego, Cal.
LEVINE, ISADORE, Bridgeport, Conn.
MACHONGA, JOHN G., Chicago, Ill.
POWELL, RICHARD F., Williamstown, Mass.
ROSENBERG, HOWARD A., Norwalk, Conn.

ADVANCEMENT TO THE GRADE OF MEMBER
(as of April 30, 1961)

KESSLER, DENNIS L., Richmond, Va.
WALBRECHT, JUERGEN, Manheim, Pa.

ADMISSIONS TO THE GRADE OF MEMBER
(as of April 30, 1961)

ABEL, CHESTER G., Englewood, Colo.
ADKINS, HARLOW D., Ridgewood, N.J.
ALBONE, HARRY G., Oakville, Conn.
ALDRIDGE, ROBERT G., Kent, Ohio
ALLEN, JOSEPH B., El Cajon, Cal.
ALUBOWICZ, BERNARD F., Tucson, Ariz.
ANDERSON, HOLMAN L., San Diego, Cal.
ANDERSON, RICHARD C., Chicago, Ill.
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AVALEAR, GARY P., Hyde Park, N.Y.

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CARBONE, MARTIN R., Sparta, N.J.
CASTO, CLYDE C., Scottsdale, Ariz.
CHANDLER, NORMAN H., Granby, Que., Can.
CHAS, WALTER M., Franklin Park, N.J.
CHOTT, HENRY JR., Covina, Cal.
CHRISTIANSEN, THEODORE W., Binghamton, N.Y.
CHRISTMAN, DEAN W., Decatur, Ill.
COHEN, MILTON R., Paterson, N.J.
COMITO, PHILIP B., Metuchen, N.J.
CONLON, THOMAS P., Albuquerque, N.M.
CONSTANTINE, GEORGE G., Clay, N.Y.
COTTLE, DONALD W., Baldwinsville, N.Y.
CRAY, E. J., Los Angeles, Cal.
CROOKE, ROBERT S., Pensacola, Fla.
CULLEN, WILLIAM S., St. John, Que., Canada
DE SANTIS, RAYMOND, Buffalo, N.Y.
DE SOUSA, ANTONIO F., Baltimore, Md.
DE WILDE, FRANK G. N., Northrand Tvl, S. Africa
DELBRIDGE, RICHARD D., Huntington Woods, Mich.
DREMEL, THOMAS A., Racine, Wis.
EMERTON, DONALD F., San Diego, Cal.
ERNY, ALLAN G., Elmira, N.Y.
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GEORGE, RICHARD E., So. Charleston, W. Va.
GILMORE, JOHN W. JR., Denver, Colo.
GREASON, W. H., Weston, Ont., Canada
GRIECO, JOSEPH W., Kenmore, N.Y.
GROSS, ALFRED E., Forest Hills, N.Y.
GROVER, PAUL G., San Diego, Cal.
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HANNA, JOHN T., Glendale, Mass.
HARRIS, EDWIN S., Middletown, Ohio
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JONES, THOMAS R., Anaheim, Cal.
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KEMP, EDWARD E., Windsor, Conn.
KINCAID, WILLIAM J., Sherburne, N.Y.
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KRANE, SCOTT A., Dugway, Utah
KRAUT, WILLI K., Metuchen, N.J.
KRETZ, WILLIAM H. JR., Willow Grove, Pa.
KUREK, THEODORE J., Baltimore, Md.
LAING, ALFRED M., Butler, Pa.
LARSEN, THOMAS C., Racine, Wis.
LECKRAND, CARL A., Orange, Texas
LEVEILLE, RAYMOND L., Fayville, Mass.
LLOYD, RALPH W., Pittsfield, Mass.
LO GALBO, JOSEPH W., No. Bellmore, N.Y.
MAC GRAW, ROBERT B., Milford, Conn.
MARQUIS, LELAND G., San Jose, Cal.
MARSIGLIO, LOUIS, Chicago, Ill.
MARTIN, JOEL H. JR., Albuquerque, N.M.
MCGOWAN, PATRICK G., Fremont, Mich.
MESCHTER, E. EVERETT, Glenside, Pa.
MOORE, FRANKLIN L., San Diego, Cal.
MURPHY, DENNIS E., Albuquerque, N.M.
MUSTY, CLYDE V., Temple City, Cal.
MUZZY, KEITH S., Holden, Mass.
NICKOL, DONALD E., York, Pa.
NIKL, LARRY, Racine, Wis.
NOWLIN, DUARD K., Albuquerque, N.M.
NOYES, CHARLES E., Pittsfield, Mass.
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OLSON, OLIVER K., Covina, Cal.
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PATTERSON, ANDREW J., Westmount, Que., Canada
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PELL, ALBERT A., Allentown, Pa.
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SCOTT, MAURICE W., Castro Valley, Cal.
SEBOKA, STANLEY J., Bellaire, N.Y.
SHENEBERGER, JACK L., Midland, Mich.
SHERRILL, ROBERT E., Merriam, Kans.
SILVERSTEIN, MURRAY, E. Meadow, L.I., N.Y.
SIMPSON, ROBERT L., Kansas City, Mo.
SINCLAIR, KENT, La Mesa, Cal.
SMITH, ALFRED E., Stockbridge, Mass.
SMITH, JAMES D., Richmond, Ind.
SOLTESZ, JOHN M., Endicott, N.Y.
STEINER, TERRY E., Wausau, Wis.
STEVENS, ROBERT B., Upland, Cal.
STRASSER, SHERMAN E., St. Joseph, Mich.
SUTTON, BILL C., Waco, Texas
SWENSON, DONALD L., Anaheim, Cal.
TALBOT, EDWIN G., Hicksville, N.Y.
TAMERSOY, BOB, Rossville, Ga.
TANCIG, WILLIAM J., Beecher, Ill.
TERENZI. E. ALEXANDER, Laurelton, N.Y.
TOCCO, CARL, Indianapolis, Ind.
TOMASKO, EDWIN A., Pitcairn, Pa.
TURNER, EDWARD M., N. Little Rock, Ark.
TURNER, THOMAS B., Lexington, Ky.
VAN WINKLE, WM. G., Saddle Brook, N.J.
WALSH, ALBERT, New York, N.Y.
WEBB, KEITH E., St. Petersburg, Fla.
WEISBROD, KEITH L., Florence, Mass.
WHITE, JAMES S., Brightwaters, N.Y.
WHITE, ROBERT L., Xenia, Ohio
WILLIAMS, ROBERT L., Baltimore, Md.
YOUNG, JOHN J., Scranton, Pa.
ZWISSLER, LEWIS E., Sacramento, Cal.

ADVANCEMENT TO THE GRADE OF ASSOCIATE MEMBER
(as of April 30, 1961)

BOLLINGER, ALVIN L., Kirkwood, Mo.

ADMISSIONS TO THE GRADE OF ASSOCIATE MEMBER
(as of April 30, 1961)

APPELL, KENNETH C., Independence, Mo.
ARMSTRONG, JERRY Q., Burlington, N.C.
BACK, RICHARD L., Hagerstown, Ind.
BRADLEY, HOWARD M., Rumford, R.I.
CARROLL, EUGENE A., Park Forest, Ill.
CLIME, VINCENT R., Philadelphia, Pa.
FRIERSON, HELEN M., Lake Oswego, Ore.
HAYES, JOHN F. JR., Somerville, Mass.
HECHT, ABRAHAM, Brooklyn, N.Y.
JOSEPH, RICHARD L., Dearborn, Mich.
KIRKLAND, FREDERICK H., Thomaston, Ga.
KWASNESKI, VINCENT F., Upper Darby, Pa.
LEE, HOWARD E. JR., Clemson, S.C.
MAPLES, RAYMOND L., Corfu, N.Y.
MCEVENEY, EDWIN, Cedar Rapids, Iowa
MCLAUGHLIN, JOHN J., North Merrick, N.Y.
MEADE, DEAN F., Aurora, Colo.
MILLEVILLE, HOWARD P., Park Ridge, Ill.
OXLEY, GLENN M., Richmond, Ind.
PEACOCK, ROBERT A., Cadillac, Mich.
PIERCE, ELDON W., Oneonta, Ala.
REECE, VIOLET H., Richmond, Ind.
SCHLEIFFARTH, ARMIN D., Kirkwood, Mo.
SCHOFIELD, ROBERT B., Huntington, L.I., N.Y.
SHARP, MERRITT A., Centerville, Ind.
SNIVELY, FRED C., Westville, Ill.
STEWART, NORMAN C., Muskogee, Okla.
STRAFFORD, JOHN J., Knoxville, Tenn.
THOMPSON, HOWARD E., Dugway, Utah

STUDENT ENROLMENTS
(as of April 30, 1961)

SICKLER, CLIFTON J., Rochester, N.Y.
VILLARD, RONALD L., Rochester, N.Y.

section briefs

As a section project, the Charleston section has undertaken the support of a local fund campaign by providing statistical information for the solicitation of funds. T. H. Heiskell, section secretary, is shown receiving the citation from Ned Chilton, fund chairman, at the annual Awards Dinner.

AKRON-CANTON . . . Apr. 28, the Third Annual Seminar held at Akron University got off to a bang-up start with Leonard Seder's effective presentation, "How to Evaluate a Company's Quality Needs" . . . Interest in the various areas of QC activity was evidenced by the approximately equal attendance at the four concurrently scheduled afternoon sessions . . . Seminar co-chairmen Norton Miller and Tom Sharkey and their committee are to be commended for their excellent program.

May 3, graduation ceremonies for QC courses one and two were held at the Massillon Club . . . A social hour preceded the awarding of certificates . . . Lawrence A. Bedford, past chairman, Akron-Canton section, addressed the group . . . Harold Baker awarded 21 certificates for QC one and Larry Miller and Bob Archer presented 20 certificates for QC two . . .

H. P. Pierce

ALLENTOWN-BETHLEHEM . . . Apr. 12, our meeting was devoted to presentation of problems and experiences of local individuals . . .

After a very tasty dinner, we were treated to two very fine talks by members of our own section. The first by Charles Moore, instructor of industrial engineering, Lafayette College, Easton, Pa., dealt with "Visual Concepts of Distributions." The second, by Bruce Tynan, paper research chemist, Dixie Cup Co., Easton, Pa., described "Machine Malfunctions Discovered by Control Charts."

David F. Roberts

BALTIMORE . . . Apr. 18, Dr. Edward J. Delate, E. I. DuPont de Nemours & Co., Inc., Wilmington, Dela., spoke on "Experimental Design and Market Research."

In attempting to evaluate which of a number of varieties of a product a company should market, it becomes apparent that one cannot expect a member of a test panel to properly evaluate more than a few of a number of varieties of a product. During his talk, he considered ten varieties, including a competitive one. Methods of applying a standard experimental design to this marketing problem as well as the analysis and interprctation of the results were discussed.

A. M. Reek

BATTLE CREEK-KALAMAZOO . . . Apr. 20, Post Club House, Battle Creek, Mich., "Purchasings' Viewpoint of Quality Control" by Earl H. Nelson, director of Purchasing, Checker Motors Corp., Kalamazoo, Mich. . . .

Apr. 27, our Forum committee met at the home of Dr. Andrew C. Luff in Kalamazoo to make final arrangements for the First Annual Forum sponsored by the Battle Creek-Kalamazoo section . . .

Peter F. Koets

BUFFALO . . . Apr. 24, Niagara Manor, Kenmore, N.Y., Dr. Charles R. Hicks, assistant dean, School of Science, Education, and Humanities, Purdue University, with "Statistical Thinking for Engineers" . . .

Dr. Hick's presentation was an introduction to basic principles of statistics which are useful to engineers. This was illustrated by a discussion of tolerances, the need for designed experiments, and the use of control charts.

Dr. Irving Gordon

CENTRAL ILLINOIS . . . Apr. 25,, during the annual meeting in Springfield, Ill., the section voted adoption of the model bylaws for sections, and elected the following slate of officers: chairman—John A. Henry, University of Illinois; vice chairman—Roderick S. Brough, Caterpillar Tractor Company, Decatur, Ill., and secretary-treasurer—H. E. Jackson, Wagner Castings Company, Decatur, Ill. . . .

Chairman R. E. Schuman, A. E. Staley Co., outlined the substantial progress made in consolidating and extending the work of the section.

Charles L. Matz, Chicago section, gave an extremely informative talk on "Quality Control Methods Applied to Electric Meter Testing." Representatives of a local meter manufacturer and several electric utilities were invited guests.

John A. Henry

CHICAGO . . . It's always a pleasure to report good things happening to nice people, and the nice person this time is Dr. Mae-Goodwin Tarver of Continental Can Co.

Dr. Tarver was the recipient of the "Joe Lisy Award" at our May 17 General Meeting.

This was the second presentation of the coveted award —last year's initial award going to Charles Matz (who is taking life easy since his recent retirement).

As all those of the Chicago section know, this award is given to one whose accomplishments, tireless efforts and never ending interests further the aims and maintain the high standards of ASQC.

Hold on, there's more! She was recently awarded a Fellowship by the Society and was selected by the Chicago section to attend the Quality Control Engineering Course given by the Society at West Point, N.Y., June 9-14.

Congratulations from all of us in the Chicago section and we sincerely hope the good things keep coming.

P.S. I'll have the names of the elected officers for the 1961-62 season in the next issue.

John Dittrich

CLEVELAND . . . Apr. 7, the regular "Timely Topic" discussion had an international flavor with Dr. I. M. Chakravarti of the Indian Statistical Institute talking on "A Simplified Test on the Median in a Two Sample Comparison." Dr. Chakravarti is a visiting professor at Case Institute of Technology. In the regular meeting, G. E. P. Box, University of Wisconsin, discussed "Automatic Optimization." We all were impressed by the possible savings from the use of this technique developed by Mr. Box.

Apr. 13, the section was pleased to jointly sponsor a meeting with the Northeast Ohio Chapter of the American Foundrymen Society. Dr. J. M. Juran presented "Motivating for Quality" to an audience of 225 persons.

Howard O. Schmat

COLUMBUS . . . Apr. 19, a special technical session was held at the Olentangy Inn Hotel. Associate Professor Albert Bishop, Industrial Engineering Department, Ohio State University, conducted a very interesting session on statistical methods of problem solving and development of practical QC practices.

G. E. Arris

CORNING-ELMIRA . . . Apr. 11, R. M. Hofstead, assistant director, Bristol Laboratories, Syracuse, N. Y., discussed the need for qualified people so that best results might be obtained from quality control programs.

Officers for the 1961-62 season are Larry Lalor, chairman; John Gailey, vice chairman; Joseph Sheehe, secretary, and Robert Goldsmith, treasurer. With this talent at the helm, we are looking forward to a very active and productive year.

Richard Gibson

DALLAS-FORT WORTH . . . Apr. 13, Harold C. Waite, district representative for Brown and Sharpe Manufacturing Co., honored the section with a return engagement . . .

Mr. Waite presented a short talk to the section in January, and many of the members asked that he be rescheduled as a main speaker.

He made a very good pictorial presentation of measuring tools from the six-inch scale to the latest in optical measuring devices. Mr. Waite was very well received, and we would highly recommend him for any of the sections in the Southwest States and in Mexico.

July 20, members and guests will have an opportunity to visit Mrs. Baird's new Bakery in Dallas, Texas . . . This bakery is completely automated, and this should prove to be a very interesting tour . . .

R. R. Massegee

DENVER . . . Apr. 28, the Engineers' Club was the setting for our meeting to hear A. S. Kaminski, chief product inspector, metrology section, Rocky Flats Plant, Dow Chemical Co., present "The Art of Metrology" . . .

The talk covered the development of measuring devices from the time of cart construction with wooden axles and wheels to the use of measuring by light ray—methods used in establishing and maintaining a secondary reference laboratory, the checking of gage blocks, and other measuring devices. He noted that cleanliness leads to accuracy in gaging.

C. E. Ell

GREATER DETROIT . . . Apr. 26, the section met for a tour of the Stroh Brewery, which was followed by dinner at local restaurant . . .

After dinner Thomas W. Brown, chief inspector, Food and Drug Administration, Detroit Area, spoke on "What We Eat and Drink."

He told us that the three principle areas which the Food and Drug Administration wishes to watch are 1) dangers to health, 2) aesthetic considerations, and 3) economic protection of the public. We saw actual items in these areas which have been removed from the market by the Food and Drug Administration.

Officers for 1961-62 are chairman—Morris M. Lightstone, Chrysler Missile plant; vice chairman—James Barrabee, Hoover Ball and Bearing Co.; secretary—Fred C. Taylor, Rickle Malt Co., and treasurer—Joseph H. Molner, Houdaille-Hershey Corp. Directors will be Dr. C. C. Craig, University of Michigan; Owen Keeler, Chrysler Corp.; and Thomas L. Harvey, Central Specialties Division, King-Seeley Corp.

Frances D. Huntington

GREATER MUSKEGON . . . Apr. 20, the section held a joint meeting with the Grand Rapids section at the Spring Lake Country Club . . . 109 members and guests heard J. Y. McClure, president, ASQC, present a slide illustrated talk on quality control . . .

Several plant tours were arranged while Mr. McClure was in the area. Plant tours in the Muskegon area included the Bennett Pump Division of John Wood Co., Brunswick Corp., and Anaconda Wire and Cable, and in Grand Rapids, Lear, Inc.

Several meetings are scheduled for the summer months to prepare for our first All Day Clinic on Quality Control to be held at the Occidental Hotel on Sept. 30, 1961. Merrill Bailey, a past president of our Society, is the general chairman. He will be assisted by William Poe, our 1961-62 president elect, Jack Fortenbacher, Mike Pascavis and Elwood Presley—the latter two past presidents of our Society. We are in the process of contacting guest speakers and instructors for the clinic.

Several other meetings will be scheduled to prepare for our annual QC courses at Muskegon Community College.

William A. Hume

HAMILTON-MIDDLETOWN . . . July 19, 7 p. m., Thompson Park, Hamilton, Ohio, joint meeting of all incoming and outgoing officers of the Hamilton-Middletown and Cincinnati sections . . . Installation of officers and a discussion of the joint program for the coming season . . . Refreshments will be served . . .

Lon Ely

HARRISBURG . . . Apr. 5, pre-meeting clinic and dinner meeting at the Castiglia's Restaurant . . .

Harmon S. Bayer conducted the clinic and presented his interesting paper "A Quality Control Program Should be a Cost Reduction Program."

Points stressed in the clinic session were increase in inspection to cover government requirements; proper instructions, procedures; good material handling; process capabilities and good working conditions.

Since this was the section's Management Night, the subject was well chosen as Mr. Bayer showed methods he proposed to establish a goal and to bring about a proven cost reduction program.

He suggested that the quality engineer determine where to start by choosing the jobs which are the chief producers of defects. Check the scrap reports, operators, machines, raw materials, customer rebates, overtime, rework time, and inventory records to determine the items and defect percentages involved.

Through the use of slides, he showed that defects cover a small portion of the total of items produced.

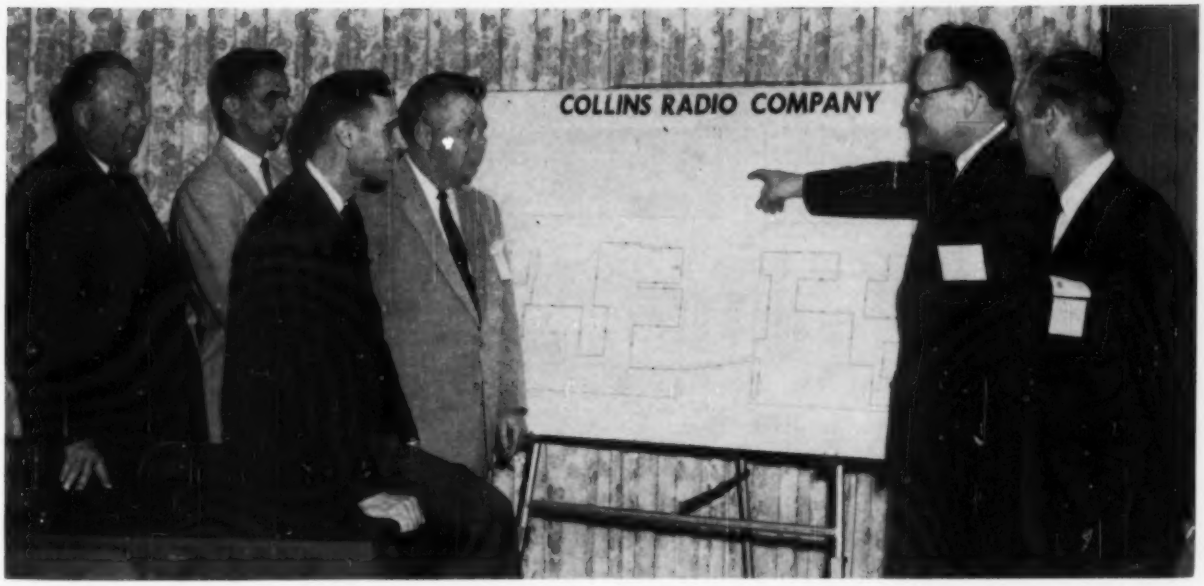
Ann Englehart

HARTFORD . . . Officers for 1961-62 are chairman—Eugene Ellis, a QC engineer, Pratt & Whitney Aircraft; vice chairman—Lawrence Sespaniak, supervisor of operations research, Pratt & Whitney Aircraft; treasurer—Conrad Chilone, QC manager, Anemostat. However, Mr. Chilone had to resign because Anemostat is moving to Scranton, Pa. Charles Dennis, QC manager, Cramer Controls, was appointed secretary.

Mr. Ellis has appointed the following committee chairmen: program—Toni Kasmerski, Stanley Works;

Paul L. Musser

The Society and the Harrisburg section wishes to extend sympathy to Mrs. Edythe Musser in the death of her husband, Paul L. Musser, who died April 20, 1961.



HOSTED BY COLLINS RADIO COMPANY in Cedar Rapids, Iowa, these engineers were among 45 participants from eastern Iowa and western Illinois who took part in a two-day meeting of the American Society for Quality Control, State University of Iowa section, Apr. 28-29. Discussing the physical plant layout of Collins Radio Company are from the left, G. J. Narigon, E. E. Lawson, P. A. Temple, J. J. Logsdon, Myron F. Wilson of Collins, and J. P. Hawley.

arrangements—Jack Hunt, Cramer Controls; education —Robert Phelps, Royal McBee, and membership—Martin Kestem, Dynamic Controls.

L. Sespaniak

HUNTSVILLE . . . The April meeting consisted of a short business meeting and dinner at the Elks Club and a tour through Huntsville Manufacturing Co., a Division of M. Lowenstein.

Officers for 1961-62 are S. J. Courtenay, Jr., chairman; K. S. Lucas, vice chairman; R. E. Courtney, secretary, and Barry E. Davis, treasurer.

The Huntsville Manufacturing Company is the largest textile plant in Alabama and processes only cotton material. The tour began at the Company's new blending facilities which had been placed in operation a week before the tour. Cotton of various types is blended to give a more uniform final product. The tour continued through all operations such as carding, spinning, and weaving. Since most of the members had never seen textile operations, it was a most interesting evening.

Barry E. Davis

STATE UNIVERSITY OF IOWA . . . Apr. 28-29, 50 members and guests attended a two day conference held in Cedar Rapids, Ia. . . .

Included in the program was a plant tour of Collins Radio Co., Cedar Rapids, Ia., where visitors saw the fabrication and assembly operations of radio and electronic equipment.

The featured speaker of the evening program was Dr. A. A. Lippisch, director of the Collins Aerodynamics Laboratory. He entertained the guests with a talk on "Aircraft of Yesterday and Tomorrow."

The program was concluded on Saturday morning with a talk by Dr. Fred Leone, Case Institute of Technology, Cleveland, Ohio, on "SQC—Some Old Concepts and Some New."

E. B. Godsey

KANKAKEE-JOLIET . . . Apr. 3, D'Amico's Restaurant, Joliet, Ill., Walter T. Hayter, a quality control metallurgist, Youngstown Sheet and Tube Co., East Chicago, Ind., spoke on "Process and Quality for Management" . . .

In addition to explaining some of the procedures used in their plant for the improvement of product quality through the use of process control charts, he also discussed some rather unique methods of reporting data to production management. He stressed the responsibility of quality control in accurately processing data and the importance of reporting this information in a concise manner which is readily understood by everyone.

Results of the election of officers for the 1961-62 year were announced by Miss Mary Egges, chairman of the nominating committee. Those selected to serve are Charles Grosche, chairman; Robert McKeague, vice chairman; Arley Wilson, treasurer, and Bob Hartman, secretary.

John E. Rauworth

KANSAS CITY . . . Apr. 20, Robert Schin, Western Electric Co., Grandview, Mo., made an interesting presentation on "Process Control of Electronic Manufacturing." . . .

Mr. Schin is assistant superintendent, Operating-Semiconductors, and also has the responsibility for QC and technical investigation. From 1941-54, he held various supervisory positions in manufacturing at Western Electric. From 1954 to 1960, he was department chief of quality control at Allentown, Pa. The Kansas City section welcomes Mr. Schin to its membership.

The annual election produced its usual good results. Cliff Cutler, Hallmark Cards, succeeds himself for another term as section chairman. Other officers are vice chairman—Lester Scott, Western Electric Co.; secretary—Wilbur D. Gay, Bendix Corp., and treasurer—Herbert L. House, GSA.

H. Afton Taylor

LEXINGTON . . . Apr. 20, T. R. Bainbridge, assistant superintendent, Quality and Standards Department, Tennessee Eastman Co., Kingsport, Tenn., presented "t-Test Techniques," one of the clearest and best illustrated discussions of the application of a statistical technique to manufacturing tests that we have heard.

Officers for 1961-62 are chairman—Glenn E. Padgett, Lexington Lamp plant, General Electric Co.; vice chairman—Archie H. Dedman, Lexington Signal Depot; treasurer—William H. Eckert, Electric Typewriter Division, IBM Corp., and secretary—James C. Graff, Lexington Lamp plant.

James C. Graff

LIMA . . . Apr. 11, Standard Oil Co., Lima, Ohio . . . With the aid of slides and measuring devices, R. Decker presented "How Sohio Inspectors Apply Statistical Methods" . . . He showed how they were able to overcome some problems through the use of statistical methods . . .

Aug. 13, Annual Family Picnic, Lima Ordnance Picnic Grounds . . . Entertainment will be available for the young, the young at heart, and those who may not fall into either category . . .

E. K. Anderson

LOS ANGELES . . . Apr. 25, Aerojet-General, one of the nation's leading producers of liquid and solid rockets and power plants, became the section's leading quality panel, attracting 609 members and guests.

Aerojet's Quality Panel, which includes various department heads, hit strongly at "The Quality Team Approach." Roy L. Queen, director of development services and manufacturing division, Azusa plant, explained how integrated planning and proper team coordination has doubled production, reduced rejection by a factor of four, and reduced unit cost by 25 percent. Mr. Queen gave the following quality team objective: Doing more, faster, for less.

July 6, IAS Bldg., 7 p.m., "Soldering Inspection Techniques" by P. Moran, Army Ordnance, and B. Kleinhofer, Missile and Space Division, NAA . . .

July 22, One Day Workshop, Inspection Division, for information, contact G. Drake, Army Ordnance, Rocketdyne, DI 7-5651, Ext. 2597 . . .

S. Kozich

LOS ANGELES—VALLEY SUBSECTION . . . Apr. 27, Henry Renand, president, Photo Chemical Corp., gave a very interesting talk on paint and corrosion protection at the monthly meeting at the Van Nuys plant, RCA . . .

N. Chilikos

MEMPHIS . . . Apr. 18, second annual Ladies' Night featured William F. Schroder, vice president, Humko products, who made a very interesting and informative presentation on "The Manufacture of Shortening and Oils" . . .

The section is grateful to Mr. Schroder for stepping in at the last minute after circumstances beyond control made it necessary for the scheduled speaker to cancel the engagement.

Officers for the 1961-62 season are Raymond L. Ross, chairman; William L. Dickerson, Jr., vice chairman; Douglas W. Ferris, secretary, and Joe I. Chance, treasurer.

Lee Dickerson

MID HUDSON . . . Apr. 4, Hotel DiPrima, Highland, N. Y., "A Corollary to Measurement Problems" by Lewis R. Wallace, staff engineer of the Measurements Standards Program, IBM Corp., Kingston, N. Y. . . .

This was an interesting and informative talk outlining some of the measurement problems confronting industry due to the advanced scientific and technological requirements for the manufacturing of precision and miniaturized equipment. Mr. Wallace also presented a brief resume of our national measurement problems and discussed how industry can most effectively put to use the forthcoming solutions.

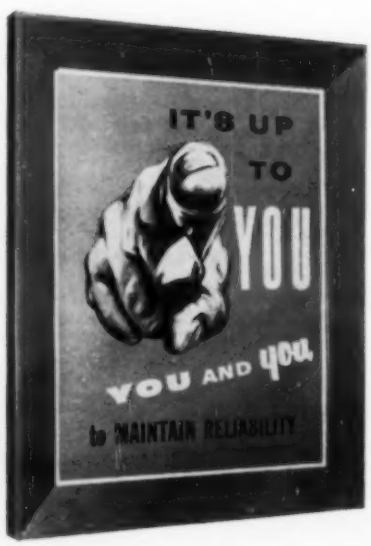
May 4, J. M. Juran spoke of the change in attitude, knowledge, and pride of workmanship of the craftsman of past years compared to the modern day worker . . .

E. L. Leadbitter

MILWAUKEE . . . Apr. 17, AC Spark Plug, the Electronics Division of General Motors Corp., Oak Creek, Wis., was host to the Milwaukee section members and guests . . .

The evening program and tour was preceded by a short business meeting and a dinner in the new AC

PROVIDING THE RIGHT CLIMATE



Cafeteria. The 167 members and guests were welcomed by a talk by Jack Briner, director of quality assurance and field service. The director of reliability, Harold C. Yost, showed color slides and lectured on "Reliability at AC Spark Plug."

The group was then divided into parties with a tour guide and proceeded through the various sections which included: tool design, tool inspection, Gyro clean rooms and test calibration, standard engineering department, systems calibration and assembly, ground support and IBM tabulating, Gyro Microsyn sub-assembly and many other areas. Points of interest and displays throughout the plant were discussed as the groups went through the various assembly and production phases.

The tour was well planned and gave an insight on the highly precision gyros and guidance systems in production, also the precision measuring instruments, both mechanical and electrical, used in their manufacture.

Cleanliness is another important factor at AC-Milwaukee. One area is actually cleaner than most hospital operating rooms and has a complete change of air every four minutes using air conditioning to avoid dust particles.

Darrell G. Schroeder

MINNESOTA . . . Apr. 11, members of this section were enlightened and entertained by Harmon Bayer, QC Consultant, who elaborated on his recent article in *Industrial Quality Control* on "Quality Control and Cost Reduction Programs" . . .

Several case histories and simple methods of determining problem areas were presented . . .

With our final business meeting in May, the section will pause for the summer, gathering energy to carry out what promises to be a busy 1961-62 program with Bill Brown, our newly elected chairman.

Violet M. Rice

MONTREAL . . . Apr. 12, the regular monthly meeting turned into a most interesting group discussion on the training of personnel in industry . . . The topic — "Getting Results from Your Training Program," a paper prepared by E. N. Beckett, Northern Electric Co., Montreal . . . The 28 in attendance, including nine guests, entered enthusiastically into the discussion . . . In his concluding remarks, Mr. Beckett said that people are motivated by their own interests and therefore we must present interesting topics to capture their attention . . .

J. J. Fitzsimons

NEW HAVEN . . . May 9, a panel discussion on "Problems of Quality Control and Inspection" was held at the Winchester Club House . . . Jack Bradshaw, supervisor, Quality Control Engineering, employed by Royal McBee Corp., moderated the session . . .

Henry Pianka, section chairman, has acquired chairmen for various committees to assist in the section program for the coming season.

Joseph F. Panczak

NORTHEAST TENNESSEE . . . Apr. 11, Peerless Steak House, Johnson City, Tenn., pre-session clinic by Sam Myers covered purchasing and quality control . . . After the clinic, a steak dinner was followed by election of officers . . .

The main speaker, J. A. Mitchell, Tennessee Eastman, presented "Experiments in a Chemical Plant," during which he related the need for technical experts in chemistry to become more proficient in conducting experiments. He also expanded on the costs and risks involved in chemical plant experiments and the need for efficiencies to reduce them.

In attendance were 28 members and 24 guests.

Mike Gomez

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OMAHA-LINCOLN . . . Apr. 14, Marcio's Steak House, Omaha, Nebr., "Safeway and the Image of Quality" by L. C. "Brick" Hawley, public relations manager . . .

T. C. Anker

ORANGE EMPIRE . . . Apr. 18, Anaheim Bowl, Anaheim, Calif., "Automation in the Receiving Inspection Function" by Howard Todt, senior member, ASQC, and assistant to the vice president, Quality and Logistics, North American Aviation . . .

The highlight of Mr. Todt's talk concerned specialized automatic testing devices for primary electrical components which were designed and developed at North American Aviation and in which he played a major role.

Henry W. McKee

PARKERSBURG . . . Apr. 12, Chancellor Hotel, members and their guests were treated to a fine talk by J. T. Atkins, E. I. DuPont de Nemours & Co., Inc., on "Computer Systems for Laboratory Use" . . . A film of the 1960 Olympics was shown prior to his talk . . .

Robert R. Stewart

PENSACOLA-MOBILE . . . Apr. 13, dual meeting in Pensacola starting at 4:30 p.m. with a plant tour through St. Regis Paper Co. . . .

The tour for both members and their wives included two pulp and paper mills, manufacturing bleached kraft paper and board, natural kraft and the multi-wall bag plant. A dinner-meeting was held at the Holiday Inn with one of our members as speaker. Ben Ferguson, International Paper Co., Mobile, spoke on "Beta Ray Profiler."

Walter D. Nencka

PHILADELPHIA . . . Apr. 13, the annual plant tour was an eventful occasion that brought out members not usually seen at regular meetings . . . Maybe more tours should be scheduled . . .

The General Electric Co., 6901 Elmwood Ave., Philadelphia, Pa., was our host for 50 members. Supervisory personnel toured us through the huge high and low voltage switchgear departments.

After the tour we assembled in the auditorium where a movie on laboratory processes and testing of Switchgear was shown. Guest speaker Harold E. Strang, vice president and consulting engineer of Switchgear and Control Division, delivered an important message on the organizational structure of the Company's Group and Operating Divisions, pointing out responsibilities associated at this level. Our thanks to all who contributed to the success of the program.

Stan Hart, section chairman, announced the results of the election of 1961-62 section officers — T. J. Moran, chairman; R. P. Davis, vice chairman; D. K. Snodgrass, secretary, and A. G. Dettore, treasurer.

Membership report shows nine additions for March, making a record total of 341 members.

Albert G. Dettore

SECTION CALENDAR

Dallas-Fort Worth
July 20, Mrs. Baird's Bakery, Dallas, Texas, 7:30 p.m.

Lima
Aug. 13, Lima Ordnance Picnic Grounds, 12-8 p.m., Annual Family Picnic for Lima section members and families.

Los Angeles
July 6, IAS Bldg., 7 p.m., "Soldering Inspection Techniques," by P. Moran, Army Ordnance, and B. Kleinhofer, Missile and Space Div. of NAA.

July 22, IAS Bldg., All Day Inspection Workshop, Chairman — Gordon Drake, DI 7-5651, Ext. 2597.

San Diego
July 15, Town and Country Hotel, 7:30 p.m., Installation Dinner Dance

PITTSBURGH . . . Dr. J. Edward Jackson discussed the technical problems involved in trying to control multivariable processes. He showed how to determine if the process was in control and also showed methods for determining the source of difficulty in out-of-control situations. Examples of multivariable techniques were shown from application to ballistic missile testing and color film processing. The simplicity of the techniques and potentially wide application was demonstrated beyond question.

Chester R. Smith

PITTSFIELD . . . Apr. 6, the executive committee met at the Stanley Club. This was an open meeting to allow the membership to make any changes in the proposed Bylaws before they were accepted. After several discussions, the bylaws were accepted with only one change.

Apr. 12, Ladies' Night, tour of the Metrology Laboratory, Ordnance Dept., General Electric Co.

The tour was conducted by members of the department, with gifts for the ladies at the entrance to the lab. The men were requested not to ask questions, but to let the ladies do the talking. (Who could stop them?) The tour of the laboratory was very interesting, well conducted and enjoyed by all. Following the tour, we were shown a demonstration of the new $100,000 wire winding machine. This machine places wires of predetermined length in predetermined patterns and strips and winds the ends around predetermined terminals. The wire length, pattern and terminal are chosen via punch card system.

Following the tour we had dinner in the Stanley Club, during which results of the election for new season officers were announced. Following the very delicious dinner, there was dancing to midnight.

Howard J. Greenslet

RHODE ISLAND . . . The election of officers keynoted the April meeting. Section officers for 1961-62 are chairman — Raymond Fourner, Brown and Sharpe Manufacturing Co.; vice chairman — Joseph Kowalski, Cornell Dublier Co.; secretary — Robert Rumazza, General Electric Co., and treasurer — Frank Bliven, U.S. Rubber Co.

The section voted to continue our sponsorship of a 30-week course in basic quality control at the University of Rhode Island Extension Division. Members participate as instructors, thus broadening their experience through college level instruction.

Paul K. Moffat

ST. LOUIS . . . At the April meeting of the St. Louis section, it was announced that the following individuals had been elected to office for the 1961-62 fiscal year: Murray Whitehead, chairman; Herbert Bock, vice chairman; Carl Soderstrom, secretary; H. O. Hehner, treasurer; E. H. Barnett, Sam Huston and Eric Corbett, directors.

Apr. 22, the annual All Day Conference sponsored by the section considered the "Anatomy of Reliability" and was attended by 130 persons. The feature attraction of the conference was the luncheon speaker, E. M. Flesh, engineering manager for Project Mercury for McDonnell Aircraft Corp., who spoke on "Management's Evaluation of Quality Control and Reliability."

W. W. Paris

ST. PETERSBURG-TAMPA . . . The local QC course was completed May 1. Instructors in the "problem solution" course were Bill Fenn and Cal Wyatt of General Electric Co., and Harold Snyder of ECI. Class enrollment consisted of 29 individuals from all phases of local industry.

An executive committee meeting was held at the home of Fred E. Steele on May 3. Program arrangements for the final meeting of the year were discussed. Installation of officers as also conducted at that time.

Harold L. Goldberg

SAN DIEGO . . . July 15, 7:30 p.m., Town and Country Hotel, Installation Dinner Dance . . .

Your reporter, on behalf of the section's entire membership, takes this opportunity to express thanks for a job well done to our outgoing officers and congratulations as well as a wish for continued success to the incoming slate. Additional high caliber programs on a level with that delivered by Dr. Solomon at our April meeting will go a long way toward insuring the section's future success.

L. I. Fredrickson

SAN FRANCISCO . . . Lt. Col. T. C. Huke, legal advisor to the Air Force Western Contract Region, addressed the section in April. He presented the basic contract philosophy of the Air Force Quality Assurance Program. By selecting a dozen examples of review cases, he skillfully explained contract appeals and interpretations, responsibility of inspectors and ambiguous specification problems.

M. R. Hubbard

SOUTHERN CONNECTICUT . . . During February and March, the Southern Connecticut section sponsored courses in basic statistical quality control. These courses were given in both Bridgeport and Norwalk, Conn., and were instructed by Howard Levinson, supervisor of quality engineering, Norden Division, United Aircraft Corp. Both courses were well attended and students gained much from Mr. Levinson's skillful presentation of the subject.

Apr. 12, Men's Clubroom, Bryant Electric Co., Bridgeport, Conn., "Zero Point One" by Albert M. Dexter, Jr., director of metrology, Pratt and Whitney Co., reported progress in splitting an inch into ten million parts. Mr. Dexter spoke of his experience at the National Bureau of Standards in the project of ultra-precision measurement.

William E. Wells

SOUTHERN ILLINOIS . . . Apr. 20, the section met in Marion, Ill. . . . Simon D. Krasner covered rating systems . . . The subject was general enough to cover almost anything that could be rated and well enough explained so that all understood.

Officers for 1961-62 are chairman — Virgil Wimmer, Olin; vice chairman— Cecil Touchon, Universal Match; secretary-treasurer — Curtis Kurtz, Norge, and director — Cliff Statler, Universal Match.

C. O. Touchon

SYRACUSE . . . Apr. 18, T. Schultz, Consultant, Manufacturing Services, General Electric Co., presented "Management Looks at Quality Control Training" at the Turners Club . . . The program was aimed at providing information concerning structuring of Quality Control training courses . . .

Apr. 29, K. L. Teegarden, section chairman, participated as moderator at the All Day Conference on Quality Control at Cornell University. The event was sponsored by the Corning-Elmira and Binghamton sections.

Lee E. Huyler

TOLEDO . . . May 13, the annual husband-and-wife picnic at Devil's Lake, Mich., was a huge success . . . Food was delicious and steaks were perfectly charcoal broiled to suit each person's individual taste . . . The Toledo section wishes to thank our hosts for the use of their lovely home on the lake, the M & S Manufacturing Co., Hudson, Mich., and Keith Lewis for the kind hospitality extended our members. Mr. Lewis was assisted by Margaret A. Tobin.

Officers installed at the outing are Margaret A. Tobin, chairman; Roy C. Settergren, vice chairman; James C. Clark, secretary; Beatrice M. Dorn, treasurer, and Wayne A. Raab, Hilton C. Fetting and John R. Meeker, board of directors.

Miss Tobin, her officers and committees have some splendid plans worked out for an interesting and beneficial year ahead.

Carwin L. Elwick

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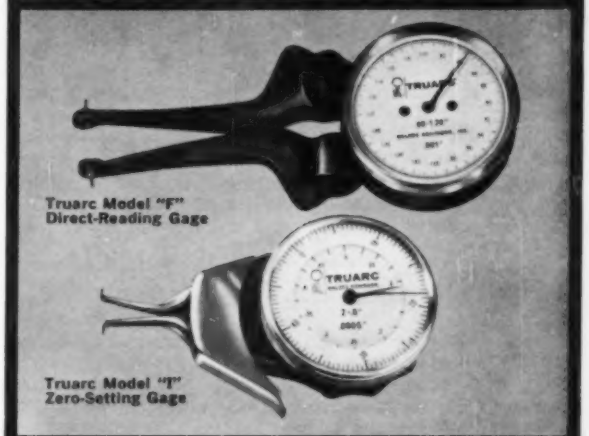

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F-177	1.00 — 2.00	.0025	2 - 3/8	$35.00
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TRENTON . . . Apr. 27, Trenton Technical Institute, Trenton, N.J., "Assuring Quality in Ammunition Material" by a panel from the Frankford Arsenal, Pa. . . . Panel members were William Haniman, chief, acceptance inspection office; Albert Dettore, chief, artillery process inspection section; Adolph Mall, assistant chief, quality assurance section, and Jerry Braverman, chief, quality assurance section.

J. Mazakis

WASHINGTON, D.C. . . . Apr. 19, Enoch Ferrell, Bell Telephone Laboratories, delivered a very instructive talk on "Reliability and Its Dependence on the Control of Quality" . . . Mr. Ferrell stressed that reliability should be considered in two parts — predictability and Suitability . . . The necessity for such characteristics in electronic parts and systems was pointed out in the design of the components for the Trans-Atlantic Cable . . .

The Washington, D.C., section has increased in membership over the year 1960-61 by almost 40 percent. Continued efforts are needed in order to maintain this growth pattern.

Eugene Tucker

WESTERN MASSACHUSETTS . . . Apr. 11, F. J. Sindelar, QC manager, Data Systems Division, International Business Machines Corp., Poughkeepsie, N.Y., presented "Manufacturing Performance Analysis" which reviewed the method for control of an assembly line process with emphasis on reporting methods designed to assist the manufacturing function in maintaining process control.

Frank A. Metze, manager, Systems Engineering, Springfield office, IBM, acted as host for the evening and introduced the speaker.

At this meeting, which was very well attended, the following officers were elected for the 1961-62 season: chairman — Anthony F. Scalise, Wico Ignition Division, West Springfield, Mass.; vice chairman — John L. Aldrich, Technifax Corp., Holyoke, Mass.; secretary — Albert Kindrick, Strathmore Paper Co., West Springfield, Mass.; and treasurer — Lynwood P. Dunphy, Westinghouse Electric Corp., Springfield, Mass.

Alan J. Donnelly

WINDSOR . . . Apr. 27, the Windsor section and the Western Ontario Chapter, American Society for Metals, had a joint dinner meeting at the Drop Inn Tavern, Windsor, Ont. . . .

After the fine dinner was finished, the guest speaker was introduced.

August Monri, chief metallurgist, Steel Company of Canada, Ltd., Hamilton, Ont., presented an excellent talk on "Control of Quality in Steel Making." Mr. Monri explained the duties of the metallurgical departments in the various areas of steelmaking. This function is important in the control of current material, research and the various special steels required by the customers. At all points in the manufacture of steel, Quality Control is the password.

Roy Mackay, QC, Ford Motor Co., Oakville, was honored at this meeting. Roy, a very good friend to the Windsor section, as presented an ASQC tie pin. The sincere best wishes of the section go with Roy to Oakville. The new executive is planning an interesting program for the coming year which will encompass all phases of inspection and quality control.

A. J. Hewitt

Wayne E. Wing

It is with deepest regret that the Parkersburg section reports that Wayne E. Wing passed away March 13, 1961. Mr. Wing has been active in Quality Control for several years and was section membership chairman at the time of his death. The section wishes to express its sympathy to his family in their great loss.

WORCESTER . . . Apr. 17, annual plant tour, Carling Brewing Co., Natick, Mass. . . . Don Davison, QC manager at Carling, conducted the tour and described the QC functions in brewmaking . . .

The section concluded on Apr. 17 a successful series of five lectures on "Quality Control for Beginners." The lectures were conducted by Axel U. Sternlof, Consultant.

Daniel J. Burda

Significant Differences

. . . ALLENTOWN-BETHLEHEM — **Dick Zwickl,** our genial chairman, attended a five week course at the Coliseum, New York, N.Y., conducted by Western Electric Co., and consisting in graduate engineering work in statistical quality control.

Officers for the 1961-62 season as elected in April are chairman — **Bryn Hammarstrom,** Sandura Co., Fullerton, Pa.; vice chairmen — **Charlie Weeks,** Bethlehem Steel Co., Bethlehem, Pa., and **Jim Miller,** Western Electric Co., Allentown, Pa., and secretary — **Harold Spaulding,** Dixie Cup Co., Easton, Pa.

Eleven members completed the section's eight-week course in Sampling Inspection. It was conducted by **Bob Tust,** Western Electric Co., Allentown, Pa.

. . . BUFFALO — At the meeting Apr. 24, the following officers were elected: chairman — **Joseph L. Gioele,** Carborundum Co., Niagara Falls, N.Y.; vice chairman— **Vernon R. Grom,** Scott Aviation, Lancaster, N.Y.; secretary — **Wilbur Burns,** Harrison Radiator, Lockport, N.Y., and treasurer — **Albert J. Ritter,** Hooker Chemical Corp., Niagara Falls, N.Y.

. . . CLEVELAND — The section congratulates Dr. **Lloyd S. Nelson** on his appointment as Society Director from Region Seven. Dr. Nelson is with the Lamp Division, General Electric Co., Cleveland, Ohio.

. . . CORNING-ELMIRA — The Corning Glass Works has recently welcomed **William R. Barker, Alan Erny,** and **Norbert Lauer** as members of the company's Statistical and Quality Control Engineering Department.

Donald F. Ludlum, Corning Glass Works, has been promoted by the company to the position of quality control auditor.

. . . DALLAS-FORT WORTH — Officers for the 1961-62 year are chairman — **Glen H. Parmeter,** Convair, Fort Worth, Texas; vice chairman — **M. R. (Bob) Seldon,** Vought Astronautics; secretary — **Vincent H. Chamberlain,** Menasco Manufacturing Co., and treasurer — **Harry W. Shifflett,** Texas Instruments, Inc.

In addition, two new directors were elected. They are **R. R. Massegee,** Convair, Fort Worth, Texas, and **Paul W. Reagan,** Texas Instruments, Inc. **Sam L. Dennison,** Dallas Air Procurement District, was appointed to fill Mr. Seldon's unexpired term as director.

. . . GREATER DETROIT — **John J. O'Brien** has been named to head a new quality assurance activity at the Plymouth Manufacturing and Engineering Division of Burroughs Corp. He has been engineering services manager, with long experience in the digital computer and automatic control fields. He will work under **A. W. Rockhoff,** technical assistant to the general manager.

Donald H. Hayes has been appointed quality assurance manager with the Military Equipment Division, Fruehauf Trailer Co. In his new position, Mr. Hayes will be responsible for planning and carrying out inspection procedures on procurement packages for Nike ground support wheeled vehicles.

. . . GREATER MUSKEGON — **John G. D. Welch,** QC manager, Gardner Denver Co., Grand Haven, Mich., has taken a similar position at Precision Cast Parts, Inc., Portland, Oregon. The latter Company manufactures investment castings.

. . . HARRISBURG — **Nicholas Gekas** and **Richard E. Wise,** AMP Inc., Harrisburg, are now quality engineering administrators of the Terminal Products and Wiring Devices Divisions, respectively. In addition to their regular quality engineering responsibilities, they will be responsible for all design and procurement of related gages.

H. A. Gross, the new section chairman, has announced his 1961-62 committee chairmen as follows: Program— **Irvin Bentzel,** Borg-Warner; arrangements — **Paul E. Bucher,** Bearings Company of America; membership — **D. Chester Conner,** Hamilton Watch Co.; education — **Elmer D. Kern,** York-Hoover Corp.; publicity — **Juergen Walbrecht,** Raybestos Manhattan Co.; auditing — **Herbert O. Pueschner,** Bendix; examining — **Nelson R. Lupold,** Caterpillar Tractor Co.; professionalism — **James T. Skelton,** Caterpillar Tractor Co.; technical societies representative — **Donald C. Yohe,** Bendix, and Saddoris Award chairman and reporter for IQC — **Ann C. Englehart,** RCA.

. . . HARTFORD — **Chic Chilone** is moving along with Anemostat to Scranton, Pa. Chic was a valuable asset to the executive committee of the Hartford section.

Jack Hunt is now with Cramer Controls, Centerbrook, Connecticut.

Kenneth A. Merz has been appointed director of engineering for the Air Moving Divisions of the Torrington Manufacturing Co., Torrington, Conn., producer of fans, blower units and wire-forming machinery.

Mr. Merz will be responsible for setting overall standards for all air moving engineering at the firm's plants in Torrington, Van Nuys, Calif., Rochester, Ind., and Oakville, Ontario. Product engineering, production engineering and quality control are major areas in which Merz's central staff organization will provide guidance.

Mr. Merz, who has been with Torrington in various engineering capacities for 12 years, has for the last year been engineering manager of the Torrington, Conn., Air Impeller Division.

. . . STATE UNIVERSITY OF IOWA — Officers elected for the 1961-62 season are chairman — **Everett E. Lawson,** Dexter Division, Philco Corp., Fairfield, Ia.; vice chairman — **M. F. Wilson,** Collins Radio Co., Cedar Rapids, Ia.; secretary-treasurer — **Paul F. Cahalan,** Inspector of Navy Material, Cedar Rapids, Ia., and three year director — **Robert E. Cannon,** Eagle Signal, Moline, Illinois.

. . . LEXINGTON — **Jack K. May** has been named project manager-quality control, with the assignment of all electronic products at Lexington IBM.

Charles Jones was appointed manager, quality engineering-electronics at IBM.

Don Gaines is now associate quality control engineer in the Quality Engineering Department, IBM.

. . . LIMA — **Earl Schmieding** was recently promoted to assistant foreman of quality control, Small Motor Division, Westinghouse Corp., Lima, Ohio. Mr. Schmieding is a graduate of the University of Nebraska with a BSEE degree. He joined the Westinghouse Graduate Student Program in 1959 and later transferred to Lima as a manufacturing trainee.

. . . LOS ANGELES — The Los Angeles section submits the April meeting — Aerojet's panel with 609 in attendance — as a national record for just a monthly meeting. Hats off to W. E. Campbell, director of reliability and quality, and Bob Deruent, ASQC booster, Aerojet-General, for the excellent job and a possible national record!

. . . METROPOLITAN — **John Wilder Tukey,** professor of mathematics, Princeton University, has been elected to the National Academy of Sciences. The academy is a Federally chartered organization that, in addition to honoring distinguished scientists by election to membership, also advises the Government on scientific matters.

. . . MID HUDSON — **Walter W. Wagner,** section chairman, has announced his committee chairmen for the coming year. A meeting of this group was held prior to the May 4 regular section meeting to complete plans for the coming year.

William Tuceling, general chairman of the One Day Seminar to be held Sept. 16 at Vassar College, reports that plans are well underway and all committees are functioning at full strength.

. . . MONTREAL — The date for the Montreal section's Fifth All Day Forum is Oct. 28. It will be held at the Ecole Polytechnique.

Committee chairmen for the 1961-62 season are immediate past chairman — **F. Clow,** Canadair Ltd.; program — **A. Dufresne,** Johnson and Johnson; membership — **J. Richer,** Johnson and Johnson; education and training — **R. Lessard,** Ecole Polytechnique; professional development — **J. B. Pringle,** Bell Telephone Company of Canada; publicity — **J. J. Fitzsimons,** Canadian Marconi Co.; arrangements — **D. Park,** Steel Company of Canada; auditing — **C. I. Taylor,** Trans-Canada Airlines; All Day Forum — **Miss I. Loutit,** Northern Electric Co., and director at large — **G. Belcher,** Canadian International Paper.

Top Boss

Secretaries Honor Society President

J. Y. McClure, president, ASQC, and quality control manager, Convair Division, General Dynamics Corp., Fort Worth, Texas, has been named "boss of the year" by Trinity chapter, National Secretaries Association (International).

An engraved copper-bronze statuette and certificate of recognition was presented to Mr. McClure by Mrs. J. W. Ocheltree, master of ceremonies, during the chapter's Executives' Night Dinner Apr. 26 at the Colonial Country Club, Fort Worth, Texas.

Mrs. R. T. Leith, secretary to Mr. McClure and a member of Trinity chapter, recommended and sponsored Mr. McClure on the basis of professional achievements and his contributions to community affairs.

The candidate's background is submitted by the secretary of the candidate. It is prepared by her (and not edited), and submitted to a committee which makes the selection.

A candidate must be a man or woman who is a top executive of a nationally or internationally famous organization, or who has made an important and outstanding contribution to his or her field and is very well known to people in that field but not as well known to the general public, or a person in business, government, arts or professions who is nationally or internationally famous.

Mr. McClure is also a member of American Management Association, American Society for Metals, and Society for Non-Destructive Testing. He is active in the activities of the Fort Worth YMCA and is on the board of Southwest Area Council, YMCA. He is a member of Central Christian Church.

One hundred members and guests attended the annual dinner, which is given during Secretaries' Week to pay tribute to employers of NASA members.

. . . NORTHEAST TENNESSEE — New officers for the coming year are **Bill Morgan,** chairman; **Ralph Debusk,** chairman elect; **Charley Stone,** director; **Jerry Hudson,** treasurer, and **Tom Odum,** secretary.

R. W. Keeney has left Raytheon to become QC manager at Kearfott General Precision Inc., Ashville, N.C.

John Daly has left Raytheon to become QC manager of Universal Moulded and Plastics, Bristol, Va.

. . . OMAHA-LINCOLN — Officers for 1961-62 are **Edward Hayes, Jr.,** chairman; **R. W. Mills,** vice chairman; **Dave Vaudewater,** secretary, and **John J. Pappas,** program chairman.

. . . ORANGE EMPIRE — **E. L. Silfen,** former QC manager, Semi-Conductor Division, Hughes Products, is now manager of reliability at Ling Temco Co.

. . . PENSACOLA-MOBILE — On Apr. 13, our section announced the new officers for the coming year. They are chairman — **Ed Remy,** Chemstrand Corp.; vice chairman — **Fred Seguin,** U.S. Air Force; secretary — **Ed Doyle,** St. Regis Paper, and treasurer — **C. O. Weinmann,** American Cyanamid.

C. M. Jones, Sr., vice president with Kahn Manufacturing Co., Mobile, Ala., is now South Eastern Division Manufacturer for McGregor.

. . . PHILADELPHIA — **Peter Graziano,** SKF Industries, Inc., was recently promoted from QC engineer to manufacturing superintendent, General Spherical Bearing Unit.

Apr. 27, members **Jerry Braverman, William Haniman,** and **Albert Dettore** presented a panel discussion at the Trenton section on "Assuring Quality in Ammunition Material."

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New appointments at Hunter Spring Co., a Division of American Machine & Metals, Inc., Lansdale, Pa., include **C. J. McClintock** to manager of quality control and inspection and **Benjamin S. Seward** as manager of quality assurance.

In his new position, Mr. McClintock will be directly responsible to the General Manager of the division. He was formerly Chief Inspector at Hunter.

Mr. Seward will be responsible to the manager of quality control and inspection for quality control systems and procedures, training, and records. Previously he was QC manager for the Turbo Machine Co., Lansdale, Pa.

. . . PITTSFIELD — **John T. Hanna,** a native of Burlington, Vt., has been named to the engineering staff of the QC department, Peter J. Schweitzer Co., a division of Kimberly Clark Corp. Mr. Hanna is a graduate of the University of Southern California where he majored in chemistry.

Theodore E. Schultz, Manufacturing Operations and QC Services, General Electric Co., New York City, has been promoted to manager of quality control of Ordnance Department in Pittsfield, Mass. Mr. Schultz has a record of service with the General Electric Company dating back to 1950. He has served in many phases of the quality control department.

. . . RHODE ISLAND — **Warren Howard,** past chairman and charter member of the Rhode Island section, formerly new products development supervisor for U.S. Rubber Co., Providence, R.I., is now manager of development for extruded filaments for the Wall Rope Co., Beverly, N.J. **Frank Bliven,** section treasurer, has been advanced to supervisor, new products development, U.S. Rubber Co., replacing Mr. Howard.

R. Shaw Goldthwaite, national director, ASQC, has been elected chairman of the New England Quality Control Conference for 1961-62.

. . . ROCHESTER — **John J. Holland** has been appointed section manager in charge of the reliability, value, and materials engineering laboratories in the Military products Division of General Dynamics/Electronics.

Prior to his new assignment, Mr. Holland was manager of quality assurance in the division for several years. For the past 18 months he has been manager for a multi-million-dollar automatic test equipment project for the Federal Aviation Agency.

He assisted in formation of the General Dynamics Reliability Panel, and served as program chairman for the panel in 1958 and 1959.

He holds a bachelor's degree in mechanical engineering from Villanova College.

. . . ST. PETERSBURG-TAMPA — Congratulations to **Fred E. Steele,** section chairman, who has just been promoted to QC manager of Incoming Materials, General Electric Co., St. Petersburg, Fla.

L. Frank Robinson, senior member, has been transferred from the St. Petersburg plant to the Irmo plant in South Carolina. Good luck, Frank, on your new assignment!

. . . SOUTHERN CONNECTICUT — **Michael J. O'Callaghan,** QC engineer, General Electric Co., Bridgeport, Conn., has transferred to the Schick Co., Lancaster, Pa., where he will be employed as a statistician.

. . . SOUTHERN ILLINOIS — **Simon D. Krasner** now works for the Crab Orchard Plant, Universal Match Corp., as quality assurance and reliability supervisor. Mr. Krasner was formerly with the Air Force in St. Louis.

. . . WASHINGTON, D.C. — **Charles E. Sener, Jr.,** vice president of C and P Telephone Co., has been elected president of the Controller's Institute of America. Congratulations!

70 Papers, 76 Authors Present New Ideas In 1961 Annual Convention Transactions

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HERE IS A LIST OF THE PAPERS CONTAINED IN THE 1961 CONVENTION TRANSACTIONS

MANAGEMENT

How to Evaluate a Company's Quality Control Need
Quality Cost Control
Quality and Reliability Management
Total Quality Control in Smaller Industries
A Challenge to Labor and Management
Breadth or Depth, Training for Quality Control and Operation Research
Operations Research in Management
Process and Quality Control for Management

PRODUCT APPLICATIONS

Getting Started in Statistical Quality Control
Benefits of Quality Control Inputs in Preparation of Specifications
Why Quality Requirements Must Be Upgraded
Some Recent Developments in Process Control
Statistical Methods for Ceramic Process Control and Experiment Planning
An Introduction to Cumulative Sum Charts

TEXTILE

Variations Flow Analysis for Process Improvement
A Practical Analysis of a Successful SQC Installation in High Quality, High Style Garment Manufacturing
Moisture Control in the Cashmere Industry

QUALITY CONTROL TRAINING

SQC Training for the Chemical Industry

NON-PRODUCT APPLICATIONS

SQC Methods in Telephone Transmission Maintenance
Measuring Relay Contact Erosion
New Departures for Operations Problems
The Human Equation in Quality Control
Bayesian Decision Theory and Statistical Quality Control
Work Sampling

RELIABILITY

Management's Challenge for Product Reliability
How RCA Meets AGREE Test Requirements
Reliability—A Management Problem
Reliability Requirements in Part Specifications
Effective Quality Control Increases Polaris Reliability
Quality Control and Reliability Organization —A Professional Approach
An Adaptation of the MIL-STD-105B Plans to Reliability and Life Testing Applications
Which Road to Satellite Reliability
Reliability Instrument Panel
Myths & Realities in Reliability
Electronics Reliability—A Mechanical Problem
Optimization of Equipment Effectiveness

DATA PROCESSING

Computing Equipment Used for Statistical Studies in the Metals Industry
Mechanized Retrieval of Scientific Information

VENDOR-VENDEE

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A Contractor Writes a Military Specification
MCTSA Seeks Quality with Confidence
Signs of our Time Which Forecast Quality
Navy Progress in Quality Control and Reliability in 1960
Qualifications for Military Quality Control Personnel
Slicing the Pie

PRACTICAL APPLICATIONS

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Test Performance Charts
Industrial Application of Non-Parametric Statistics
Keep It on the Square
Short Cut Statistical Methods as Applied to Certain Reliability Problems
Hunting and Taming the Wild Observation

RESEARCH AND DEVELOPMENT

Designing Valid Experiments
Response Surface Techniques as a Statistical Approach to Research and Development in Ultrasonic Welding
Quality Control in Research and Development
Controlling Quality in the Production Engineering Climate

SENSORY QUALITY CONTROL

A Quantitative Approach to Classification of Characteristics
Subjective Product Evaluation Methods
Putting the Senses to Work in Quality Control
Statistical Aids to Visual Inspection
Value Analysis and Engineering

INSPECTIONEERING WORKSHOP

Organization of the Inspection Function for Maximum Effectiveness
The Inspection Engineering Approach
A Survey of Visual Inspection
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Dial Gage Maintenance, Repair & Calibration
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JUNE

. . . **26-30**—Eleventh Annual Program of Quality Control for the Graphic Industries, Towne House Motor Inn, Rochester, N. Y., fee $250, contact Harold M. Kentner, director, Extended Services Division, Rochester Institute of Technology, Rochester 8, N. Y.

. . . **26-30**—Aero-Space Electricity Conference, AIEE, Benjamin Franklin Hotel, Philadelphia, Pa., contact J. A. Scarcelli, General Electric Co., 3198 Chestnut St., Philadelphia, Pa.

. . . **28-30**—Second Joint Automatic Control Conference, University of Colorado campus, Boulder, Colo., sponsored jointly by ISA, AIChE, AIEE, ASME and IRE. General program chairman is H. M. Paynter, Mechanical Engineering Dept., Massacnusetts Institute of Technology.

JULY

. . . **10**—Three Week Conference in Transport Phenomena for engineering teachers, a project supported by the National Science Foundation through a recent grant of more than $40,000 to the University of Wisconsin. Transport phenomena includes the subject matter areas of fluid dynamics, heat transfer and diffusional processes. A living and travel allowance will be awarded to teachers on the basis of qualifications contained in applications submitted. The NSF grant provides stipends for approximately 80 participants. Contact Professor Paul J. Grogan, administrative director. Conference on Transport Phenomena, University Extension Department of Engineering, University of Wisconsin, Madison 6, Wis.

. . . **17**—Fundamental Techniques and Industrial Applications of Radioactive Isotopes, July 17-Aug. 11, a special course offered by the University of Virginia Division of Extension and General Studies and In Cooperation with the U. S. Atomic Energy Commission. Persons with bachelor degrees, or the equivalent in experience, which includes at least one year of college chemistry and one year of college physics, are eligible to apply. The over-all cost of the course, covering tuition, lodging, meals, and study materials, is $475, including an enrollment fee of $25, payable at the time of application (this will be refunded to those not accepted). Contact Dr. James W. Cole, Jr., Box 3697, University Station, Charlottesville, Va.

. . . **31-Aug. 11**—Statistical Methods in Industry series of seven concurrent courses at the University of California, Los Angeles, Calif. Courses are QC by statistical methods; industrial statistical methods; statistical design and analysis of industrial experiments; probability and statistics of reliability; engineering and management of reliability; basic measurements and standards, and fundamental principles of non-destructive testing. Contact Edward P. Coleman, Professor of Engineering, University of California, Los Angeles 24, Calif.

AUGUST

. . . **6-18**—Fourth Annual Institute on Missile Technology, University of Connecticut, Storrs, Conn., contact Albert L. Jeffers, Box U-56, University of Connecticut, Storrs, Conn.

. . . **21-31**—Basic QC Course, University of Michigan, Ann Arbor, Mich., contact C. C. Craig, Statistical and Computing Laboratory, 106 Rackham Bldg., University of Michigan, Ann Arbor, Michigan.

. . . **28-Sept. 1**—International Heat Transfer Conference, Boulder, Colorado, con. ct American Society of Mechanical Engineers, meetings department, 29 W. 39th St., New York 18, New York.

. . . **29-Sept. 1**—66th Summer Meeting of the American Mathematical Society at Oklahoma State University, Stillwater, Okla., contact American Mathematical Society, 190 Hope St., Providence 6, R. I.

SEPTEMBER

. . . **5-15**—Statistical Methods and Advanced QC Course, Irving W. Burr, instructor, Purdue University, Lafayette, Ind., contact Statistical Laboratory, Engineering Administration Bldg., Purdue University, Lafayette, Indiana.

. . . **6-8**—Joint Nuclear Instrumentation Symposium sponsored by ISA, AIEE, and IRE, at North Carolina State College, Raleigh, N. C. Contact ISA Meetings Manager, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

. . . **10-22**—Twelfth Annual Statistical Quality Control Institute, University of Connecticut, Storrs, Conn., contact Theodore A. Toedt, coordinator, University of Connecticut, Storrs, Conn.

. . . **11-15**—16th Annual ISA Instrument-Automation Conference, Biltmore Hotel, Los Angeles, Calif. Contact ISA Meetings Manager, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

. . . **12**—**Eighth Annual Bay Area Quality Control Conference, Stanford University, Palo Alto, Calif. Contact W. Grant Ireson, Head, Industrial Engineering Department, Stanford University, Palo Alto, Calif.**

. . . **16**—**16th Michigan Quality Control Forum, Angel Hall, University of Michigan, Ann Arbor, Mich. Contact Dale A. Cue, Hoover Ball and Bearing Co., 5400 South State Road, Ann Arbor, Mich.**

. . . **16**—**The Scope of Quality Control, Granata Hotel, San Antonio, Texas, sponsored by the San Antonio section, ASQC, contact Robert W. Worrick, 239 E. Ackard Pl., San Antonio 21, Texas.**

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. . . **19-20**—Registration for two-semester credit courses, September 1961 through May 1962, at the Carnegie Institute of Technology. Courses cover probability and mathematical statistics, experimental design, and quality control and industrial statistics, and will meet one evening a week, 7:30-10:30 p.m., Wednesday, Thursday, and Friday evenings, respectively. Registration Sept. 19-20 from 6:30-9 p.m. For further information regarding graduate and undergraduate day courses, contact Professor Edwin G. Olds, Department of Mathematics, Carnegie Institute of Technology, Pittsburgh 13, Pa.

. . . **21-22**—Industrial Electronics Symposium, Bradford Hotel, Boston, Mass., sponsored jointly by the AIEE, ISA, and the Professional Group on Industrial Electronics of the IRE. Contact D. J. LaCerda, Badger Manufacturing Co., 363 Third St., Cambridge, Mass.

. . . **28-29—Two-day QC Training Program, University of Chicago, downtown campus, Chicago, Ill., contact J. C. Dittrich, Victor Adding Machine Co., 3900 N. Rockwell St., Chicago 18, Ill.**

. . . **28-30—ASQC Chemical Division Conference, Hotel Daniel Boone, Charleston, W. Va., contact Jack L. Massau, E. I. du Pont de Nemours and Co., P. O. Box 993, Charleston 24, W. Va.**

OCTOBER

. . . **9-11**—National Electronics Conference, International Amphitheatre, Chicago, Ill. Sponsors include the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University, and the University of Illinois. Participants are Electronic Industries Association, the Society of Motion Picture and Television Engineers, Iowa State University, Marquette University, Michigan State University, Purdue University, University of Michigan, University of Notre Dame, University of Wisconsin, and Wayne State University. Contact NEC, 228 N. LaSalle St., Chicago 1, Ill.

. . . **22-25**—Fall Meeting of the National Fluid Power Association, Sheraton Hotel, Philadelphia, Pa. Contact National Fluid Power Association, 5595 N. Hollywood Ave., Milwaukee, Wis.

. . . **24-25—Product Maintainability Working Seminar, Sheraton Hotel, Philadelphia, Pa., sponsored by the Electronics Division, ASQC. Contact B. W. Marguglio, Martin Co., Mail No. 2000, Baltimore 3, Md.**

NOVEMBER

. . . **9-10—Eleventh Annual Conference of the Aircraft and Missile Division, ASQC, Ambassador Hotel, Los Angeles, Calif., theme—Assuring Customer Satisfaction, four concurrent series of sessions on international and general interest, design—reliability, production—quality control, and field service—maintainability. Contact Hardy Harris, publicity chairman, c/o North American Aviation, Inc., International Airport, Los Angeles 45, Calif.**

ASQC Annual Convention

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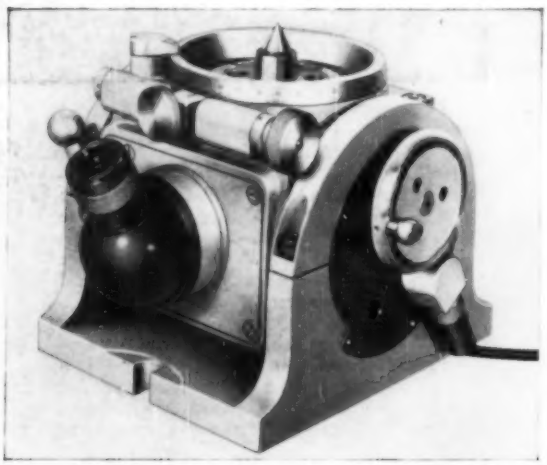

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